

CRS Report for Congress

Received through the CRS Web

Missile Defense: The Current Debate

Updated December 21, 2005

Coordinated by Steven A. Hildreth
Specialist in National Defense
Foreign Affairs, Defense, and Trade Division

Missile Defense: The Current Debate

Summary

The United States has pursued missile defenses since the dawn of the missile age shortly after World War II. The development and deployment of missile defenses has not only been elusive, but has been one of the most divisive issues of the past generation until recent years.

The Bush Administration substantially altered the debate over missile defenses. The Administration requested significant funding increases for missile defense programs, eliminated the distinction between national and theater missile defense, restructured the missile defense program to focus more directly on developing deployment options for a “layered” capability to intercept missiles aimed at U.S. territory across the whole spectrum of their flight path, adopted a new, untried development and acquisition strategy, announced U.S. withdrawal from the 1972 Anti-ballistic Missile Treaty, and has deployed an initial national missile defense capability.

The Administration argued these steps were necessary in response to growing concerns over the spread of weapons of mass destruction and their means of delivery, especially on the part of a handful of potentially hostile states and terrorists. In addition, they asserted that U.S. deterrence theory has outlived its usefulness and that conventional or nuclear deterrence could not be relied upon to dissuade unstable leaders in rogue states.

Critics, however, take issue with assertions that the threat is increasing, citing evidence that the number of nations seeking or possessing nuclear weapons has actually declined over the past 20 years. Moreover, they argue that the technology for effective missile defense remains immature, that deployment can be provocative to allies, friends, and adversaries, and it is a budget-buster that reduces the availability of funds to modernize and operate U.S. conventional military forces. They argue especially that some major powers view U.S. missile defense as an attempt at strategic domination and that other, such as China, will expand their missile capabilities in response.

This report will be updated as needed.

Contents

Most Recent Developments	1
Overview	1
Issues for Congress	1
Scope of Report	2
Missile Defense Prior to the Bush Administration	2
Bush Administration's Proposed Approach	3
Key Issues	6
Ballistic Missile Proliferation	6
Overview	6
Russia	6
China	7
Iraq	8
Iran	8
North Korea	9
India	9
Pakistan	9
Libya	10
Syria	10
Technical Issues & Acquisition Strategy	10
Hit-to-Kill	10
Layered Defenses	11
Acquisition Strategy & Congressional Oversight	13
Evolutionary Acquisition with Spiral Development	13
Exemption from Reporting Requirements	16
Information to Be Classified	17
Background on Major Missile Defense Programs	17
Boost Defense Segment	17
Air-Based Boost	17
Space-Based Boost	19
Sea-Based Boost	20
Midcourse Defense Segment	24
Ground-Based Midcourse	24
Pacific Missile Defense Testbed	24
Costs	25
Recent Tests and Technical Challenges	25
Sea-Based Midcourse	26
Ships and SM-3 Interceptor	26
Sea-Based X-Band Radar	29
Terminal Defense Segment	30
Ground-Based Terminal	30
Patriot PAC-3	30
Theater High Altitude Area Defense (THAAD)	31
Medium Extended Air Defense System (MEADS)	33
Sea-Based Terminal	34
Cancellation of NAD Program	34

Post-Cancellation Strategy	36
Sensors Segment	38
Recent Congressional Action	40
FY2006	40
FY2005	40
FY2004	41
FY2003	41

Missile Defense: The Current Debate

Most Recent Developments

For FY2006, the Bush Administration requested \$8.73 billion for the Missile Defense Agency (MDA) budget. This includes \$3.3 billion for the Ground-Based Interceptor (GBI) program, currently being deployed in Alaska and California. The House-passed defense authorization bill (H.R. 1815) provides \$8.83 billion, an increase of \$100 million for the ground-based missile interceptor program. The Senate-passed authorization bill approved \$8.73 billion for MDA (S. 1042) and similarly specified that \$100 million of the funds provided for the Midcourse Defense Segment be used to enhance the ground-based missile interceptor test program. The House-passed defense appropriations bill (H.R. 2863) includes \$8.58 billion for MDA. It too specifies an additional \$100 million for ground-based missile defense interceptor testing. The Senate-passed appropriations bill provides \$200 million more for the ground-based missile defense interceptor program and \$65 million for the Israeli Arrow system.

Although missile defense remains strongly supported, Congress and others have raised questions and concerns over several programs, including the Airborne Laser, the SSTS (Space Surveillance and Tracking System), and the BMD System Interceptor program. Some concerns also remain over significant flight test delays in the ground-based system being deployed in Alaska and California.

Recent milestones reported by MDA include a successful intercept by the Navy's sea-based missile defense program, a successful flight test of the revamped Theater High Altitude Area Defense (THAAD) system, a successful flight test of the ground-based mid-course defense (GMD) interceptor, and deployment of the 10th operational interceptor of the GMD system.

Overview

Steven A. Hildreth & Amy A. Woolf, Specialists in National Defense

Issues for Congress

In July 2001, the Bush Administration presented to Congress the outlines of its proposed approach to missile defense. The Bush Administration's plan differed significantly from the approach pursued by the Clinton Administration. The issue for Congress remains whether to approve or modify the Bush Administration's proposed approach for missile defenses. In general, Congress has supported the President's approach, making some adjustments in programs experiencing technical problems and reducing funding for programs that Congress was not yet willing to commit to for early deployment purposes.

In December 2002, the Administration announced its decision to begin fielding initial missile defense capabilities in 2004-2005. An initial national missile defense capability was declared with the deployment of eight interceptors in Alaska and California at the end of 2004.

Scope of Report

This report provides background information on the Bush Administration's proposed approach, and discusses key issues relating to it. Key issues raised in the next section include:

- **Ballistic Missile Proliferation:** Which countries of concern possess or are developing missiles that might threaten the United States, its military forces, or its friends and allies? What range of missile threats might U.S. missile defenses be required to counter in the near and mid-term?
- **Technology issues:** Will the United States be able to develop and deploy missile defenses that can intercept missiles of all ranges and at all phases of their flights? If not, can a partial system be overcome even by rogue states? What are the key technological challenges? When might the research and development program give way to a deployment program? Will DOD's acquisition policy affect the planned incremental deployment strategy?

The latter sections of the report provide background information on the various parts of the Administration's proposed missile defense program. It includes program and budget data, and key technical challenges faced by the programs. The report concludes with a summary of congressional action on the missile defense budget.

Missile Defense Prior to the Bush Administration

The United States has pursued the development of missile defenses for more than 50 years. Since the Reagan Strategic Defense Initiative (SDI) was launched in FY1985, the United States has spent more than \$85 billion on missile defense programs and studies. Missile defense has proven to be a challenging and elusive endeavor. Moreover, the question of whether the United States should deploy extensive defenses to protect against ballistic missile attack has been one of the most divisive political and national security issues of this generation.

The demise of the Soviet Union and the debate over the emergence of ballistic missile threats from other nations changed the nature of the debate. For many, concerns about nuclear stability between the United States and Russia have receded as the two nations expanded their areas of cooperation and improved their relationship, especially in the U.S. lead war on terrorism. Instead, many now focus on concerns about a possible attack from an adversary who possesses only a few missiles and may not be deterred by fear of U.S. retaliation. Without a missile defense capability, some argue, the United States itself may be deterred from using its conventional forces to protect U.S. allies and friends. Similarly, the United States

might be unable to combat aggressive or provocative actions on the part of “rogue states” armed with chemical, biological, or nuclear capable ballistic missiles.¹ Even terrorist acquisition of ballistic missiles armed with weapons of mass destruction is today part of the policy debate.

The Clinton Administration responded to this changing international security environment by pursuing the development and deployment of defenses that would protect U.S. allies and forces in the field from attack by shorter and medium-range ballistic missiles (theater missile defense: TMD). It also sought to develop for deployment a limited system to protect U.S. territory from attack by longer-range ballistic missiles (national missile defense: NMD). Its plans for NMD would eventually have conflicted with the terms of the 1972 Anti-ballistic Missile (ABM) Treaty with the Soviet Union, which limited the United States and Soviet Union (now Russia) to a single, land-based system for defense against long-range ballistic missiles. The Administration sought to preserve the basic framework of the ABM Treaty by negotiating modifications that would have permitted the deployment of a limited, land-based NMD site in Alaska. The Clinton Administration decided, however, that it would not proceed to deploy the site after failures in the flight test program and other technical concerns raised questions about the readiness of the technology.

Bush Administration’s Proposed Approach

The Bush Administration sharply altered the debate over missile defense. In several pre-election speeches, President Bush indicated that he would pursue the development of technologies that could be deployed on land, at sea, and in space to protect the United States, its allies, and its forces overseas from ballistic missile attacks from rogue nations. President Bush also stated that the United States would have to “move beyond the constraints” of the ABM Treaty. He emphasized that “Russia is not our enemy,” and, therefore, Russia should not be concerned about U.S. deployment of missile defenses. Instead of seeking to modify the ABM Treaty so that the United States could deploy limited missile defenses, the President said “we need a new framework that allows us to build missile defenses to counter the different threats of today’s world.”²

The Administration began to outline the details of its plans for missile defenses in July 2001, after submitting its amended defense budget for FY2002 to Congress. In that budget, the Administration requested \$8.3 billion for missile defense, an increase of \$3.1 billion or 61 percent over the amount Congress funded for FY2001. The Administration stated that it would explore a broader range of technologies and basing modes, “including land, air, sea, and space-based capabilities that had been previously disregarded or inadequately explored.” However, as is described in more detail later in this report (see **Table 1**), the Administration appears to have essentially increased funding evenly for each of the missile defense and sensor technologies already in the defense budget. From a funding and programmatic perspective, the

¹ For example, see Lawrence F. Kaplan, “Offensive Line: Why the Best Offense is a Good Missile Defense,” *New Republic*, Mar. 12, 2001: 20-25.

² George W. Bush, Remarks on Missile Defense, National Defense University, May 1, 2001.

Administration did not appear to give increased priority to any particular program or introduce any major new research directions for FY2002 beyond what the Clinton Administration was already pursuing, except to accelerate the process and integrate key components. A similar argument was made with respect to the FY2003 missile defense budget of \$7.8 billion.

In its missile defense program, the Bush Administration eliminated distinctions between theater and national missile defenses (TMD and NMD). Instead, according to General Kadish, the director of MDA (formerly the Ballistic Missile Defense Organization (BMDO)), the Administration has “developed a research, development, and test program that focuses on missile defense as a single integrated BMD system.” Furthermore, the objective of this program is to “aggressively evaluate and develop technologies for the integration of land, sea, air, or space-based platforms” and to develop and deploy a global system of “layered defenses, capable of intercepting missiles of any range at every stage of flight — boost, mid-course, and terminal.”³

Administration officials have highlighted two primary benefits of layered defenses. First, layered defenses would seek to provide the United States with more than one opportunity to target an attacking missile, thus arguably increasing the chance of shooting it down. (A critique of the layered defense concept is outlined in the section on Technology and Other Challenges.)

Second, the layers could complicate an attacker’s ability to defeat the overall system. This is because countermeasures, which are intended to confuse or overcome defenses, that might be effective in one phase of a missile’s flight might not work in other phases.

The Bush Administration has emphasized that its missile defense program will concentrate on “robust research and development” into a wide range of missile defense technologies. Unlike the Clinton Administration, the Bush Administration has not yet identified an architecture (a detailed missile defense system with specific objectives and capabilities) that it will seek to deploy nor established a schedule for the development and deployment of any particular system or element; but, a clear underlying objective is the early deployment of a defense designed against missiles aimed at U.S. territory. Because it has not identified the types of technologies or the numbers of interceptors and radars that it intends to deploy, the Administration will not provide any costs for the missile defense program or system. It emphasizes that cost estimates are premature under the new approach.

Administration officials have stated that this research and development effort is “designed to develop effective systems over time ... and to deploy that capability incrementally.” The program envisions the deployment of “different combinations

³ The boost phase of a missile’s flight occurs immediately after launch, and lasts for 3-5 minutes for long-range missiles and 1-2 minutes for short-range missiles; it is the powered portion of the flight. The midcourse portion occurs after boost, outside the atmosphere and, for long-range missiles, can last up to 20 minutes. The terminal phase occurs when a missile or warhead re-enters the atmosphere; it lasts less than a minute for short-range missiles and a minute or two for longer-range missiles.

of sensors and weapons” when these technologies “are proven through robust testing.” These technologies could then be replaced by more effective or advanced systems when they become available. This approach is called an evolutionary acquisition strategy. This strategy differs from the way in which most military acquisition programs occur. It will likely be the subject of increased scrutiny. An analysis of this strategy and some of its implications follows in a subsequent section of this report.

During congressional testimony in July 2001, Deputy Secretary of Defense Wolfowitz stated repeatedly that the United States would not violate the ABM Treaty, but that the Treaty stood in the way of the Administration’s missile defense efforts. He noted that some of the tests or activities could “bump up” against the limits in the Treaty in “months not years.”⁴ However, the Bush Administration also stated that the United States would have liked to reach an agreement with Russia that would allow these tests, and the eventual deployment of extensive missile defenses, to proceed without concern for the Treaty limits.

At a meeting in Italy in July 2001, President Bush and Russia’s President Putin agreed that the two nations would hold discussions that focused on both offensive weapons and defensive systems. Some interpreted this agreement to mean that the two nations would begin negotiations on new treaties that would limit offensive nuclear weapons and missile defenses. Administration officials stated clearly, however, that these were not negotiations, but consultations. They also stated at that time the Administration did not plan simply to seek modifications in the ABM Treaty, but it would not allow the Treaty to prevent research and development toward deployment even if that ultimately meant U.S. withdrawal from the Treaty.⁵ Rather, the Bush Administration sought to convince Russia that the ABM Treaty was no longer relevant and that the two nations should agree to set it aside and replace it with a new framework for their relationship. According to some reports, the United States would share information about missile defense developments with Russia, but it would not accept any limits on research, development, testing, or deployment of its systems. Russia, however, did not accept the U.S. approach, and, on December 13, 2001, President Bush announced that the United States would withdraw from the Treaty. Actual withdrawal from the 1972 ABM Treaty occurred June 13, 2002. The Administration announced it had a specific plan for deploying an initial missile defense capability on December 17, 2002.

⁴ U.S. Department of State, Cable on Missile Defense Policy, Published by the Carnegie Endowment for International Peace, July 2001.

⁵ In late August 2001, for example, John Bolton, Undersecretary of State for Arms Control and International Security, held out the possibility of invoking the withdrawal clause by November 2001 if “meaningful progress” with Russia was not achieved.

Key Issues

Andrew Feickert, Analyst in National Defense

Ballistic Missile Proliferation

Overview. Currently, Russia and China are the only two countries that could attack the United States with intercontinental ballistic missiles (ICBMs). Although other countries with short and medium range missile programs may aspire to join this club, there are factors other than scientific and infrastructure to consider. Variables such as the availability of financial resources, political will, availability of foreign material and technical assistance, and the affects of non proliferation and export control regimes all play a role in missile development. In this regard, countries discussed here other than Russia and China should be considered as potential future threats outside of their respective regions. Within their respective regions however, these countries, along with Russia and China, will present an ever increasing proliferation challenge to U.S. forces, friends, and allies.

Ballistic missile proliferation has continued steadily over the past two decades presenting a variety of security challenges to the United States. The number of countries with operationally deployed ICBMs that could strike targets in the United States remains relatively small. There is, however, a fairly widespread and growing capability to launch shorter range missiles and a slowly evolving capacity to launch medium range missiles.⁶ These short to medium range missiles could not only threaten U.S. forces on a regional basis but could also serve as a precursor for the development of longer range missiles over the course of the coming decades. The transition from short to medium range missiles to ICBMs is more a matter of technical expertise than of technology. The principal hurdles to developing longer range missiles are manufacturing larger propulsion systems and designing a missile with more than one stage. With an existing short or medium range ballistic missile infrastructure, overcoming these hurdles becomes an issue of having an experienced and qualified scientific and engineering staff. If a country does not have this expertise domestically, it can be imported. The United States routinely monitors ballistic missile development and deployment trends in a number of critical countries. The countries listed below are those critical countries addressed in the 2002 National Intelligence Estimate (NIE) on Foreign Ballistic Developments and the Ballistic Missile Threat Through 2015.

Russia. Russia has the most significant ballistic missile inventory of all countries of concern. Russia currently has approximately 700 ICBMs⁷ capable of

⁶ Joseph Cirincione, *The Declining Ballistic Missile Threat*, Carnegie Endowment for International Peace, February 18, 2002, p. 6.

⁷ Ballistic missiles are classified by range as follows:

Short Range Ballistic Missiles (SRBMs) = 150 - 799 kms.

Medium Range Ballistic Missiles (MRBMs) = 800 - 2,399 kms.

Intermediate Range Ballistic Missiles (IRBMs) = 2,400 - 5,499 kms.

Intercontinental Range Ballistic Missiles (ICBMs) = 5,500 kms and greater.

delivering over 3,000 nuclear warheads of various yields.⁸ Russia also maintains a number of ballistic missile-capable submarines equipped with approximately 200 launchers that could deliver up to 900 nuclear warheads.⁹ Despite these seemingly significant numbers, the Russian Strategic Nuclear Forces have been in critical decline over the past decade due to a variety of internal and external factors.

Because of slower than anticipated development and also in response to the United States withdrawal from the ABM Treaty, the Russian government has slowed the production of its new SS-27 ICBM (START II compliant with one nuclear warhead) and will instead retain a significant number of its older SS-18 and SS-24 ICBMs (each capable of carrying 10 multiple independent reentry vehicles (MIRVs)) that were destined to be destroyed under START II ceilings. Russia will retain 154 liquid-fueled SS-18 Satan heavy ICBMs and 36 SS-24 Scalpel ICBMs that were supposed to be eliminated by 2007 under the provisions of START II.¹⁰ Russia's SS-27 Topol-M ICBM was first deployed in 1997 and Russia had deployed 23 SS-27s in silos as of the end of 2000.¹¹ Although designed to carry one warhead, experts believe that with modifications the SS-27 could carry anywhere from 3 to 6 nuclear warheads. Russia claims to have developed missile defense countermeasures for the SS-27 allowing the SS-27 to penetrate any known missile defense. Such countermeasures could include global positioning technology and independent warhead maneuvering capability. It is important to note that independent sources have not substantiated Russian claims on the SS-27's penetration capabilities. Over the next five years, the Defense Intelligence Agency believes that Russia will focus its limited resources on the SS-27 program, the SS-26 short range ballistic missile (SRBM), and the submarine-launched SSN-23 and Bulava-30 ballistic missiles.¹²

China. China's current ICBM force consists largely of liquid propellant, single warhead, silo-based missiles. Approximately 20 of these missiles are CSS-4 missiles that can reach targets within the United States. About 12 CSS-3 ICBMs are deployed and are most likely intended as a deterrent force to Russia, Pakistan, and China.¹³ China also has a number medium-range JL-1 submarine launched ballistic missiles (SLBMs). Concerned about the survivability of their ballistic missiles, China is focusing on the development of mobile, solid propellant ICBMs. The Intelligence Community projects that by 2015, most of China's land-based ICBMs will be mobile.¹⁴

⁸ *Foreign Missile Developments and the Ballistic Missile Threat Through 2015*, Unclassified Summary of a National Intelligence Estimate, Central Intelligence Agency, June 13, 2002, p. 10.

⁹ Ibid.

¹⁰ "Russia to Retain MIRVs Beyond Start II Deadline," *Jane's Defence Weekly*, August 28, 2002.

¹¹ *Russia: TOPOL-M ICBM Overview*, Center for Nonproliferation Studies, January 2001.

¹² "Inside the Ring," *Washington Times*, November 15, 2002, p.11.

¹³ *Foreign Missile Developments*, CIA, p. 11.

¹⁴ Ibid.

China continues to develop solid-fueled DF-31 ICBMs for both silo and mobile basing, as well as for submarine deployment. China has tested CSS-5 medium-range ballistic missiles (MRBMs) with dummy warheads or what the Pentagon calls “penetration aids” designed to defeat missile defense systems. China is assessed to be capable of developing multiple reentry vehicles (MRVs) for its CSS-4 missiles in the next few years but MRV development for its new mobile ICBMs and SLBMs would face significant technical hurdles and would be extremely costly.¹⁵ China continues to deploy short-range CSS-6 and CSS-7 missiles across the Taiwan Strait. U.S. intelligence estimates that there are about 350 Chinese missiles deployed within about a 7½ minute flight time of Taiwan. Recently, China has offered to reduce the numbers of deployed missiles if Taiwan scales back its arms purchases from the United States. China has also exported missile technologies to Iran, Pakistan, North Korea, and Saudi Arabia.

Iraq. Western Intelligence believes that Iraq has upwards of 20 Al Hussein SRBMs and about a dozen transporter, erector, launchers (TELs) in breach of 1991’s UN Security Council Resolution (UNSCR) 687.¹⁶ Other organizations, such as the London-based Institute for Strategic Studies, suggest that this number could be closer to a dozen or fewer missiles.¹⁷ Iraq has continued its short-range missile program, which is permitted under UNSCR 687, but U.S. and British Intelligence believe that they are working on extending the range of these missiles in excess of the 150 km range permitted. Iraq has also rebuilt previously-destroyed facilities and constructed new facilities designed to produce solid propellants and to test missile engines with ranges in excess of 1,000 kms.

Iran. Iran has one of the largest missile inventories in the Middle East. Iran has a few hundred SRBMs consisting mostly of SCUD-Bs, SCUD-Cs, and Chinese CSS-8 missiles. Iran has also successfully tested and deployed a small number of Shahab-3 MRBMs that could strike targets in Israel, Turkey, and most of Saudi Arabia. The Shahab-3 is based on the North Korean No Dong missile and is believed to have a range of 1,300 kms.¹⁸ Iran has also publically acknowledged the development of the Shahab-IV as a ballistic missile (later reclassified as a space launch vehicle (SLV)) with an estimated range of 2,200 kms.¹⁹ Iran is also believed to be developing a Shahab-V with an unspecified range. In all cases, Iran’s continuing development of its missile program will rely heavily on Russian, Chinese, and North Korean assistance. Despite Iran’s current efforts, most U.S. intelligence agencies believe that

¹⁵ Ibid.

¹⁶ *Iraq’s Weapons of Mass Destruction: The Assessment of the British Government*, September 24, 2002, p. 27.

¹⁷ *Iraq’s WMD - A Net Assessment*, The International Institute for Strategic Studies, September 9, 2002, p. 66.

¹⁸ *Ballistic Missile Capabilities in the Middle East*, Carnegie Endowment for International Peace, April 26, 2002, p. 2.

¹⁹ Ibid.

Iran will not be able to launch an ICBM/SLV until the later half of this decade while one agency says that a successful test launch is unlikely prior to 2015.²⁰

North Korea. North Korea's recent actions in relation to the Agreed Framework and possible "reconsideration of the missile testing moratorium" could foreshadow their resumption of missile testing. The two-stage Taepo Dong 2, which some believe could deliver a several hundred kilogram nuclear payload to Alaska, Hawaii, and parts of the continental United States may be ready for flight testing in the near future.²¹ If North Korea can successfully integrate a third stage, this could boost the Taepo Dong's range to 15,000 km — sufficient range to strike all of North America.²² North Korea also has hundreds of SCUD and No Dong missiles that pose a significant WMD threat to U.S. and allied military forces in the region. North Korea has continued to export ballistic missiles and associated technology, most notably to Pakistan and Yemen. On December 11, 2002 the Spanish military intercepted 15 SCUD missiles at sea bound for Yemen. This was later determined to be a legal shipment and was allowed to proceed. North Korea is also believed to be training missile engineers and technicians, most notably Syrian, in the domestic production of SCUD missiles.

India. India continues their aggressive domestic development of ballistic missiles, primarily to establish a nuclear deterrent to Pakistani first use of nuclear weapons and as a hedge against a confrontation with China.²³ The Prithvi I, a single-stage, liquid fueled, road-mobile missile, is currently India's only deployed ballistic missile.²⁴ India also continues to develop the Prithvi II, a 250 km SRBM. India has tested the Agni-series of MRBM with a reported range of 2,000 km. These Agni-series of missiles will likely become operational in the next few years and will become the mainstay of India's MRBM forces.²⁵ India has a domestic space launch vehicle program referred to as the Surya program. Intelligence sources believe that India could convert this SLV into an ICBM within one to two years after the decision had been made to do so.²⁶ India is actively developing the Sagarika SLBM and is attempting to buy or lease nuclear submarines with the intent of modifying the submarines to accommodate SLBMs.

Pakistan. Pakistan's pursuit of missile-delivered nuclear weapons is a considered by many experts as a deterrent to India's nuclear program as well as their numerically-superior conventional forces.²⁷ Like India, Pakistan is developing an indigenous ballistic missile production capacity and has a variety of missiles. The

²⁰ *Foreign Missile Developments*, CIA, p. 13.

²¹ *Ibid.*, p.12.

²² *Ibid.*

²³ *Ibid.*, p.17.

²⁴ *Ibid.*

²⁵ *Ibid.*

²⁶ *Ibid.*

²⁷ *Foreign Missile Developments*, CIA, p. 18.

short range (80 km) Hatf I is a simple solid propellant missile designed not only for domestic use but also for export. The Hatf III (modified Chinese M-11 missile) is a single-stage, solid propellant missile with a range of at least 300 kms. Pakistan also has a number of No Dong missiles (renamed Ghauri) from North Korea with a range of 1,500 km. Pakistan is developing and testing Ghauri 2 and Ghauri 3 missiles with reported ranges of 2,000 and 3,000 kms, respectively.²⁸ Pakistan is also developing the road-mobile, two-stage solid propellant Shaheen II with a reported range of 2,500 kms.²⁹

Libya. U.N. sanctions from 1992 to 1999 are believed to have severely limited Libya's ability to obtain the requisite expertise, materials, and equipment to continue its development of MRBMs and ICBMs.³⁰ Since the removal of sanctions in April 1999, Libya has actively attempted to refurbish its aging SCUD force as well as obtain complete, long-range missile systems through a variety of foreign suppliers. Reports suggest that Libya may have received No Dong MRBMs from North Korea, but this has not been confirmed by Western intelligence sources.³¹ Libya may be working on its Al Fatah missile that it claims has a 1,000 km range (U.S. intelligence believes the range is closer to 200 kms.) but this missile has not yet been tested.³²

Syria. Syria possesses an extensive mobile SCUD-B, SCUD-C, and SS-21 SRBM arsenal.³³ These systems could allow Syria to strike deeply into the territories of potential regional adversaries Israel, Iraq, Turkey, and Jordan.³⁴ Although Syria has not shown any overt interest in acquiring longer-range missiles, it is possible that as regional security prospects continue to deteriorate, Syria may attempt to acquire longer-range systems such as the No Dong MRBM.

Technical Issues & Acquisition Strategy

Hit-to-Kill. (*Steven A. Hildreth, Specialist in National Defense*) The concept of kinetic kill or hit-to-kill has been a primary focus of the missile defense program since the conception of the SDI in the early 1980s. Previously, the United States pursued missile defense concepts that employed nuclear weapons as interceptors. More conventional explosive warheads were used to develop the PAC-2 system used in the Persian Gulf war against Iraqi Scud missiles. Advanced and exotic concepts, such as various lasers, were largely deemed impractical during the late 1980s and early 1990s.

²⁸ *Third World Ballistic Missiles*, Teal Group World Missiles Briefing, August 2002.

²⁹ *Foreign Missile Developments*, CIA, p. 18.

³⁰ *Ballistic Missile Capabilities*, Carnegie Endowment, p. 3.

³¹ *Ibid.*

³² *Ibid.*, p. 4.

³³ *Ibid.*

³⁴ *Ibid.*

A kinetic kill interceptor would seek to destroy its intended target through a direct collision at relatively high speeds. The force of the impact would then destroy the attacking missile or warhead, render it inoperable, or divert it from its intended target. With such an approach, a near-miss has the same practical affect as a large distance miss: the target is not destroyed.

Kinetic kill as a concept for destroying short- and medium-range ballistic missiles appears to be in the process of proving itself. After a string of failed intercept tests, the THAAD program began a series of successful tests. Barring major, unforeseen technical or engineering problems, it appears that a kinetic kill warhead for THAAD can be developed. The same is true of the PAC-3 system. The next generation Patriot interceptor seems to be proving the concept of kinetic kill for short-range missile defenses, despite the most recent test failures in February 2002.

The key question remaining, however, centers around levels of effectiveness, particularly in wartime. Under test-range conditions, most military systems perform better than they do in an operational environment. The Patriot system used in Desert Storm is a notable example. Prior to the war, Patriot successfully intercepted 17 of 17 very different targets under a variety of test range conditions. Patriot encountered a vastly different operational environment when deployed, and its success or failure during the war is still debatable, and, according to experts, probably unknowable.

Kinetic kill as a concept for destroying long-range ballistic missiles is even more problematic at this stage. There is no unambiguous, empirical evidence to support the contention that kinetic kill for ICBM defense will work. Missile defense advocates argue that since the mid-1980s, a string of such tests have occurred with varying degrees of success; some have failed to achieve interception, while others were deemed successful.

But in almost every case, post-test doubts have been raised. Critics have charged that test results over the past two decades have been exaggerated by false claims of success and promises of performance that later proved false. Many tests were proven to have had their targets significantly enhanced to ensure the likelihood of success.

Some missile defense advocates say this may be true. But kinetic kill for ICBM defense is comparable to where kinetic kill was for systems such as PAC-3 several years ago. They maintain, therefore, that continued development, and especially more realistic testing, is needed to ensure that the kinetic kill concept for long-range missiles can eventually be deployed.

Layered Defenses. (*Steven A. Hildreth, Specialist in National Defense*) The concept of layered defense, which dates back to at least the 1960s, and was developed more systematically in the 1980s, envisions deploying several missile defense systems, each designed to intercept an attacking missile or warhead at a different stage of its flight trajectory. The concept arguably would allow for multiple intercept opportunities. Although this presents the possibility that one element of the system may not work as intended, proponents argue that multiple intercept opportunities significantly *increase* the chance that an attacking missile or warhead will be destroyed.

Proponents of layered defenses argue that each layer is able to attack a different vulnerability of the attacking ballistic missile and that, because each layer is statistically independent of every other layer, the probability of a warhead getting through all of the layers (1 to N) can be given by a simple multiplication of the probabilities of surviving each independent attack.³⁵ This analysis would readily lead to a conclusion that a defense with three layers, for example, might let extremely few missiles or warheads get through.

Other analysts, however, would argue that this is a wrong conclusion. In the first place, there is no empirical evidence of an air defense system with a probability of intercept (P_i) much greater than about 30 percent (or 0.3). So one might conclude more realistically that the probability that an attacking missile or warhead will survive is closer to 34 percent.³⁶ Moreover, it is argued,³⁷ even if one assumes that each layer is 90 percent effective, the layered defense model fails because the layers are *not* statistically independent for at least two reasons:

- Each attacking warhead or missile must encounter each of the layers in order, so the performance of one layer will affect the performance of the next layer and so on. For example, if the first layer underperforms because some countermeasure is unexpectedly successful, then the second layer will be required to deal with more simultaneous targets than expected; if one missile or warhead avoids interception, that may mean that circumstances are favorable for the next missile to get through also. Even if each layer is over designed by a factor of about 2, failure of one layer can still lead to saturation of the next. For example, if we expect the terminal layer to have to handle 10 warheads, we might design it to handle 20, but if earlier layers then fail so that the terminal layer is presented with 30 targets, at least 10 warheads will get through to their intended destination even if the terminal layer works perfectly. The failure of an early layer would thus result in the collapse of the missile defense system: the layered ‘pyramid’ defense is balanced on its vertex, rather than set firmly on its base.
- Until a layered defense has been tested under realistic conditions, when it must engage warheads nearly simultaneously in each layer, it is unrealistic for defense planners to assume that there are no problems of command and control among the layers, and that unknown variables do not operate to degrade the system in unpredicted ways. Such a test would be expensive and difficult to

³⁵ For example, suppose that a missile defense system consists of three independent layers, each with a kill probability of 90%. Then the probability of surviving each layer is 10 percent (or 0.10), and the probability of surviving all three layers is $0.10 \times 0.10 \times 0.10 = 0.001$. In other words, in such a system only one missile in a thousand will get through.

³⁶ $0.7 \times 0.7 \times 0.7 = 0.343$; that is, 34% of the missiles or warheads would survive this layered missile defense system.

³⁷ A critique of the layered defense concept is developed by Peter D. Zimmerman, “Pork Bellies and SDI,” *Foreign Policy* (Summer 1986): 76-87.

achieve, requiring the multiple simultaneous launch of several ICBMs.

The probability of an attacking warhead surviving intercepts by three “correlated” layers cannot be known without making assumptions about the mechanism of the correlation and non-independence of the layers. In general, critics conclude the performance of the system may be no better than the performance of the best layer, and then only if that layer is not saturated by the sheer numbers of missiles, warheads, or countermeasures.

Layered defense proponents are likely to understand, and perhaps agree, with many of these points. But supporters will respond by suggesting these issues can be adequately addressed in the design of a missile defense architecture and adjustments made during its development (see below).

Acquisition Strategy & Congressional Oversight. (*Gary Pagliano, Specialist in National Defense*) Some observers, particularly critics of the missile defense program, have expressed concern that the Administration’s overall approach for managing the program could hinder Congress’s ability to conduct effective oversight of it. Three areas of the Administration’s management approach are at issue: The first concerns the Administration’s plan to use evolutionary acquisition with spiral development to develop and acquire missile-defense systems. The second concerns a DOD directive that exempts the missile defense program from certain reporting requirements that are normally applied to major defense acquisition programs. The third concerns a decision to classify certain missile defense testing and program information.

The Administration and its supporters argue that these three developments are needed to help the program proceed expeditiously and to help prevent potential adversaries from learning how to evade or overcome U.S. missile-defense systems when they are deployed. Critics argue that these three factors could reduce Congress’s ability to understand, track, and thereby conduct effective oversight of the Administration’s missile defense program. Each of these three developments is discussed below.

Evolutionary Acquisition with Spiral Development. (*Gary Pagliano, Specialist in National Defense*) In presenting its new missile defense program to Congress in 2001, the Administration announced that missile defense systems would be developed and acquired under a relatively new approach called evolutionary acquisition with spiral development, or spiral development for short. As discussed in another CRS report,³⁸ spiral development is an outgrowth of the defense acquisition reform movement of the 1990s, and represents a departure from the traditional DOD approach for developing and acquiring major weapon systems. Spiral development is aimed at achieving certain widely accepted defense-acquisition goals, including the following: (1) getting usable increments of a weapon capability into service sooner; (2) mitigating technical risk in acquisition programs involving

³⁸ CRS Report RS21195, *Evolutionary Acquisition and Spiral Development in DOD Programs: Policy Issues for Congress*, by Gary J. Pagliano and Ronald O’Rourke.

new or emerging technologies; (3) taking advantage of user feedback in terms of determining how to modify and improve the system; and (4) facilitating the incorporation of new technologies into the system design during the system's life cycle.

Missile defense was the first major weapon acquisition program to be publicly linked with spiral development. DOD officials, however, have stated that they want spiral development to be the new "default" (i.e., standard) acquisition strategy for major weapons acquisition programs, and have since announced their intention to apply spiral development to other major weapon acquisition programs, such as the Navy's DD(X) next-generation surface combatant program.

Under an evolutionary acquisition strategy, a basic version of a weapon system is developed and fielded with the intent of subsequently developing and deploying more capable versions of the system as technology and requirements are further refined. A critical aspect of evolutionary acquisition is spiral development, under which the various elements of a weapon system evolve incrementally over time in an iterative manner. Instead of attempting to develop a system that will, upon first deployment, fully satisfy a detailed military requirement, systems under an evolutionary acquisition strategy would be developed, tested, deployed, and modified in a cyclic process that, in principle, would permit weapons developers to incrementally work toward a final system configuration that is eventually capable of meeting its required objectives.

A distinct characteristic of evolutionary development is a reduced ability, particularly at the outset of a program, to define what the deployed system might look like at various points in the future. Rather than attempting to define final configuration at the outset, evolutionary development consciously treats this issue as an open question to be addressed over time as elements of the system are developed, deployed, evaluated, and modified. In this sense, the Administration's proposed missile defense effort is more of an evolving concept than a typical military system in development.

The Administration's missile defense plan would apply evolutionary acquisition and spiral development to an entire family of system development efforts related to the common mission of missile defense. Under the Administration's plan, missile defense systems would be built, tested, deployed, and evaluated incrementally. The final missile defense system or architecture — that is, the numbers and characteristics of the land-, sea-, air-, and space-based system involved — would be determined gradually over the course of several years. During this period, systems capable of performing similar portions of the missile defense mission (i.e., the boost phase, the midcourse phase, or the terminal phase) would be in implicit competition with one another for places in the final system configuration.

The Administration's plan to employ this acquisition strategy for missile defense is consistent with its view that missile defenses are urgently needed. The Administration argues that deploying missile defenses sooner with less capability than later versions is desirable because any improvement in U.S. missile defense capabilities would complicate enemy planning and thereby strengthen deterrence against ballistic missile attacks. The Administration also argues that the strategy is

appropriate for weapon acquisition programs, such as missile defense, where the fundamental technologies involved are less technically mature than they are for well-established types of weapons, such as aircraft and ships.

A major consequence of the Administration's proposed evolutionary acquisition strategy is that the missile-defense program would not feature the familiar phases and milestones of the traditional DOD acquisition system. Another consequence, already reflected in DOD testimony, is that BMDO cannot provide Congress with a description of its final missile defense architecture, the capabilities of any near- or longer-term system, the specific dates by which most elements of the emerging architecture are to be tested and deployed, an estimate of the eventual total cost of the missile-defense program, or estimates of the amounts of funding that the program will require in individual years beyond FY2002. Lt. Gen. Ronald Kadish, Director of BMDO (now MDA), stated the following to the Senate in July 2001 in introducing the Administration's missile-defense plan

But before I proceed to describe the new program in detail, I would like to make clear what this program does *not* do. It does not define a specific architecture. It does not commit to a procurement program for a full, layered defense. There is no commitment to specific dates for production and deployment other than for lower-tier terminal defense systems....

First, we are recommending a broad, flexible approach to RDT&E that allows us to explore multiple development paths and to reinforce success based on the best technological approaches and the most advantageous basing modes in order to hedge against the inherent uncertainty of the ballistic missile defense challenge. Second, we are recommending an acquisition approach that is evolutionary, one that will allow us to field systems incrementally once they are proven through realistic testing. And third, rather than committing to a single architecture as we have done in the past, we will deploy over time different combinations of sensors and weapons consistent with our national strategic objectives....

This robust RDT&E program aims to demonstrate what does and does not work. Those activities showing the greatest promise will receive greater resource emphasis. Our progress will inform an annual high-level decision-making process that will steer the BMD program in the most promising direction, taking into account optimal approaches and the most reliable information on costs, allowing informed research, production, and deployment decisions....

The business of missile defense requires coping with a number of technological, developmental, acquisition, and threat uncertainties. For this reason, I cannot tell you today what exactly the system will look like 15, 10, or even five years from now. This system will take shape over time. We do not intend to lock ourselves into a highly stylized architecture based on either known technologies or hoped for advances in technology that will take a decade or more to complete. We intend to go beyond the conventional build-to-requirements acquisition process....

Specific system choices and time lines will take shape over the next few years through our capability-based, block approach. We will increase our capability over time through an evolutionary process as our technologies mature and are proven through testing. The block approach allows us to put our best,

most capable technologies “in play” sooner than would otherwise be possible. We have organized the program with the aim of developing militarily useful capabilities in biannual blocks, starting as early as the 2004-2006 time frame....

We must deviate from the standard acquisition process and recognize the unprecedented technical challenges we are facing. We do not have major [missile] defense acquisition programs in the FY2002 budget. We do not have program activities with traditional fixed milestones and clearly marked phases showing the road to production.

The new approach to BMD development features more streamlined, flexible management through comprehensive and iterative reviews. We will establish yearly decision points to determine the status of the available technologies and concept evaluations in order to be in a position to accelerate, modify, truncate, or terminate efforts in a particular area. This comprehensive annual review process will also help us make decisions to shape the evolving systems and allocate resources to optimally support them.³⁹

The Administration and its supporters argue that the use of spiral development for the missile defense program (or other weapon acquisition programs) will not prevent Congress from conducting effective oversight, and could even improve Congress’s oversight ability in some respects, because Congress will retain its role in approving each block, or segment, in a spiral development program, and because the information that DOD provides for the block to be approved will be more reliable than the potentially speculative information it might present under the traditional acquisition approach about what the entire program might look like from beginning to end.

Critics of the Administration’s plan to use spiral development argue that it could reduce Congress’s ability to provide effective oversight by putting Congress in the position of approving the start of a program whose outlines are only vaguely defined, because the lack of an original estimate of the program’s overall quantities, cost, schedule, and cost would deprive Congress, years later, of a benchmark against which to measure performance of the program, and because the built-in potential for changes in a spiral development program could make funding projections for spiral development programs more volatile than funding projections for traditional development programs.⁴⁰

Exemption from Reporting Requirements. (Gary Pagliano, *Specialist in National Defense*) In January 2002, the Secretary of Defense issued a memorandum exempting the missile defense program from certain reporting requirements normally applied to major defense acquisition programs (even those that employ spiral development). The Administration’s stated intent in issuing this

³⁹ Statement of Lt. Gen. Ronald T. Kadish, USAF, Director, Ballistic Missile Defense Organization, on The Ballistic Missile Defense Program, Amended FY2002 Budget, Before the Senate Armed Services Committee, July 12, 2001, pages 2-3, 6-8, 14. Emphasis as in the original.

⁴⁰ See, for example, Theresa Hitchens, “The Unknown Spiral,” *Defense News*, March 11-17, 2002: 13.

directive was to help streamline the management and oversight of the missile defense program and thereby enable it to proceed more expeditiously. This objective is consistent with the Administration's interest in fielding missile defense systems without delay. Critics of the Administration's missile defense program, however, argue that the directive will deprive Congress of key program information and thereby reduce the ability of Congress to conduct effective oversight of the program.⁴¹

Information to Be Classified. (*Gary Pagliano, Specialist in National Defense*) In May 2002, the Administration announced that certain information about the missile defense program, including details about developmental tests, will henceforth be classified, and, therefore would not be released to the public. Administration officials argue that classifying the information will help prevent potential adversaries from learning about the technical characteristics of U.S. missile defense systems and using that information to design ballistic missiles with features designed to evade or overcome U.S. defenses. Critics of the decision argue that some of the information the Administration has decided to classify, such as basic details about early developmental tests, would be of no practical use to a potential adversary, and that the Administration's actual motive in limiting access to the information is to shield the missile defense program from public scrutiny and criticism.⁴²

Background on Major Missile Defense Programs

Boost Defense Segment

Air-Based Boost. (*Daniel Morgan, Analyst in Science & Technology, and Christopher Bolkcom, Specialist in National Defense*) The Air-Based Boost program, more commonly known as the Airborne Laser (ABL), would use a high-power chemical laser mounted in a modified Boeing 747 aircraft to shoot down theater missiles in their powered boost phase of flight. The laser would seek to rupture or damage the missile's booster skin to cause the missile to lose thrust or flight control and fall short of the intended target before decoys, warheads, or submunitions are deployed. The ABL's intended range is several hundred kilometers. Major subsystems include the lethal laser, a high-precision tracking system for keeping the laser beam on target, and an adaptive optics system that compensates for atmospheric effects to keep the beam tightly focused.

The ABL program was transferred to BMDO, now the MDA, from the Air Force. The MDA states there is no current system or architecture envisioned for

⁴¹ See, for example, Bradley Graham, "Rumsfeld Pares Oversight of Missile Defense Agency," *Washington Post*, February 16, 2002, p. A2; Susan Milligan, "Critics Fault Rumsfeld For Cutting Oversight Of Antimissile Plan," *Boston Globe*, March 9, 2002: 3.

⁴² See, for example, Bradley Graham, "Secrecy On Missile Defense Grows," *Washington Post*, June 12, 2002: A10; Thomas Duffy, "Levin Questions Missile Defense Agency's Classification Policy," *Inside Missile Defense*, June 12, 2002: 1; Philip E. Coyle, "Why the Secrecy Shield?," *Washington Post*, June 11, 2002; Paul Richter, "Missile Data To Be Kept Secret," *Los Angeles Times*, June 9, 2002: 1.

missile defense, including specifics for the ABL. But the Director of BMDO, in congressional testimony, has stated that “BMDO will evaluate the most promising projects” for boost-phase defense “to provide a basis for an architecture decision between 2003 and 2005.”

The most recent Air Force concept envisioned a fleet of seven aircraft. Five of these aircraft would deploy to a theater to support two 24-hour combat air patrols. These aircraft would be positioned behind the friendly line of troops and moved closer toward enemy airspace as local air superiority is achieved. The most recent cost estimate was \$10.7 billion (life cycle costs), which includes an estimated \$1.6 billion for the current program development and risk reduction phase.

The contractor team consists of Boeing, Lockheed Martin, and TRW. Boeing is responsible for the aircraft and for overall management, including systems integration. Lockheed Martin is responsible for the beam control systems, including target tracking and atmospheric compensation. TRW is responsible for the lethal laser and for ground support systems. There are numerous subcontractors.

The system currently under development will attempt its first missile shoot-down test in 2005. BMDO states this half-power ABL could be available for deployment as an emergency capability immediately following lethality demonstrations scheduled for late 2005. If all goes according to schedule, this system and the next two could provide an initial operating capability: one aircraft on station, one preparing to arrive on station, and one on ground alert between FY2009 and FY2011, depending on the results of additional operational testing.

Congressional concerns about the ABL have centered on two main issues: the maturity of key technologies and the concept of operations. First, although proponents contend that the ABL employs mature technology, others characterize key aspects (particularly the atmospheric compensation system) as experimental. Critics also claim that the tests needed to resolve this question, which are being conducted concurrently with the development of the technology, will not take place until 2005. This date is after a second aircraft is scheduled to be ordered, and just months before the first shoot-down test. The compressed and concurrent nature of this schedule also is an issue of concern.

The Defense Department’s Office of Test and Evaluation informed Congress in its FY2000 annual report (January 2001) that the 24-month EMD (Engineering, Manufacturing, and Development) program is “alarmingly short....[the schedule] allows for no technical problems or test failures, and the many integration and test activities cannot all physically be accomplished in the time allotted for EMD.” However, this schedule is likely to change due to the two year delay for the lethal shoot-down.

Second, there is disagreement about whether the ABL would be operationally effective, even if its technology performs as planned. The ability of the ABL to destroy enemy missiles at its intended range depends on a number of factors, including atmospheric conditions between the laser and the target, possible enemy countermeasures, and the worldwide trend towards deployment of longer-range missiles for theater operations. Possible technical countermeasures include

hardening the missile casing, spinning the missile, or applying a polished finish to the missile.

In addition, the ability to deploy ABL aircraft during crisis or war will depend on the ability to provide a relatively safe area of operations through air superiority. It is not clear whether enemy forces would wait for this to happen and render their ballistic missile forces more vulnerable, or see incentives to launch their missiles before ABL systems were deployed, or whether an opponent might choose to wait out a crisis because a force of ABL aircraft probably would not be deployed on 24-hour combat patrols indefinitely.

Space-Based Boost. (*John D. Moteff, Specialist in Science & Technology Policy*) The mission of the Space-based Boost intercept portion of the program is to develop the capability of shooting down ballistic missiles of any range in their boost phase (i.e., before the missiles have released their payload) from platforms located in orbit. Two concepts are under development: a space-based laser (SBL) and space-based kinetic weapons. Both concepts have been under development to varying degrees since before SDI in the early 1980s. Congressional funding support for this portion of the program is waning.

In FY2002, the Bush Administration had requested \$170 million for space-based laser development, with much of that directed toward the development of an Integrated Flight Experiment, to be conducted in space and initially scheduled for 2012, and the construction of a test facility to be located at Stennis Space Flight Center. However, Congress, concerned that the technology was not mature enough to warrant the development of the flight experiment at this time, appropriated only \$30 million for the program. As a result, the Integrated Flight Experiment (which was projected to cost between \$1 billion and \$3 billion) and the test center were cancelled. The Bush Administration's FY2003 request for the space-based laser was \$34 million, and directed primarily at reducing technical risks associated with key components (the megawatt hydrogen-fluoride laser, mirrors, beam controls, pointing/tracking/fire controls, etc.). Congress reduced the request by \$10 million in its FY2003 appropriations.

The space-based kinetic energy component of the space-based boost phase intercept portion of the program is designed to further develop the key component technologies including the kinetic kill vehicle, boosters, sensors, battle management and control, and platform integration. Development work and experiments are to help reduce the technical risks and lead to a design decision in FY2006 or later. This element was a new start in FY2002 and received \$23 million. The Bush Administration requested \$53million for FY2003 and had proposed major increases in the program in the out-years. Congress cut the request by \$50 million. In its appropriations report, the House Appropriations Committee stated that greater emphasis should be placed on accelerating the manufacture of existing systems, such as the PAC-3, and on accelerating the development of other more mature technologies.

There are a number of issues associated with space-based boost phase intercept. Any such system could also function as a anti-satellite weapon, an issue that remains highly controversial. The desirability of stationing weapons in space generates

differing opinions. Also, the technical hurdles associated with space-based interceptors — especially lasers, with their weight, size, and reliability constraints — are difficult. Feasibility is not yet certain, hence the need for the demonstration programs. At the very least, how long it will take to overcome those hurdles and at what cost remains uncertain. Although no longer a constraint, when the ABM Treaty was in force, testing and deploying these systems in an ABM mode had been prohibited.

Sea-Based Boost. (*Ronald O'Rourke, Specialist in National Defense*) The Sea-Based Boost program was created by the Bush Administration in 2001 as part of its new missile defense program. The general idea of using sea-based missiles to intercept enemy ballistic missiles in their boost-phase, however, goes back several years. The sea-based boost-defense concept is of potential interest because forward-deployed Navy ships operating off the coasts of other countries might be close enough to certain ballistic missile launch sites of concern for high-speed, high-acceleration, ship-launched interceptors to fly inland from the ship and intercept enemy ballistic missiles during the boost phase.

The sea-based boost-defense concept appears most feasible for use against missiles launched from sites that are close or somewhat close to international waters, since this would reduce the distance that the interceptor would need to fly to reach the enemy missile and thereby increase the chance that the interceptor would reach it during its boost phase. The concept might thus have the most potential for intercepting missiles launched from countries such as North Korea, Libya, or perhaps Iran. The concept would appear to offer little potential for intercepting long-range Russian or Chinese missiles, whose launch sites are located deep inland, because these missiles are more likely to complete their boost phase before a ship-launched interceptor (even one with a high-speed, high-acceleration booster) could reach them.

Although the Sea-Based Boost program is not yet well defined, a robust sea-based boost system would likely require an interceptor missile with:

- a much higher maximum speed, or burn-out velocity (perhaps 6 to 8 kilometers per second [kps]) than that of the SM-3 interceptor missile now being developed for the Sea-Based Midcourse system (which has a maximum speed of a bit more than 3 kps);
- a high rate of acceleration to maximum speed, to help meet the short engagement times associated with boost-phase intercepts; and
- a kill vehicle different from the Sea-Based Midcourse kill vehicle, because the latter is designed to operate against a small and relatively cold target, while a boost-defense kill vehicle would need to be capable of operating against a large and hot-burning target.

The first two characteristics will likely require either a major modification to the existing SM-3 missile design or the development of an entirely new missile with a diameter of up to 27 inches. Whether a modified SM-3 or an entirely new design, a higher-speed missile developed for the Sea-Based Boost program might prove suitable, with a different kill vehicle, for use as an improved interceptor for the Sea-Based Midcourse system. Conversely, a higher-speed missile developed for an

improved Sea-Based Midcourse system might prove suitable, with a different kill vehicle, for use as the interceptor for the Sea-Based Boost system. (See section on the Sea-Based Midcourse program.) Using the same basic interceptor missile for both programs could reduce total sea-based missile defense costs.

It may also be possible, as a near-term stopgap measure, to develop a more limited boost-phase capability based on the SM-3 missile. Although the SM-3 was designed to intercept slower-moving theater-range ballistic missiles rather than faster-moving intercontinental ballistic missiles (ICBMs), the SM-3 may have some potential to intercept certain ICBMs — specifically, those that are fired from coastal launch pads — during the later (i.e., exoatmospheric) part of their boost phase, before they have attained their maximum speeds.

A mid-2002 discussion of the sea-based boost concept stated:

Although the radar currently in place on Aegis combatants has enough power and resolution to detect and track ICBMs during the boost phase, the navy has optimized the system's performance and displays to defend against targets such as cruise missiles and missiles launched from airplanes. The required modifications for ICBM defense are not trivial, but they are achievable. What is totally missing at present is a suitable boost-phase missile interceptor.

Some U.S. Navy officials proposed using SM-2 Block IV⁴³ missiles to engage boosting ICBMs in the upper atmosphere; that proposal, however, was fraught with a great deal of technical risk and required the ship to be within 50 kilometers of the launch site, making the ship itself vulnerable. A more practical approach may be developing a missile interceptor intended to engage the boosting ICBM later in its boost phase above the atmosphere, allowing ships to be as much as 1,000 kilometers from the launch site.

Developers could use the SM-3 test missiles being produced for the navy's midcourse risk-reduction effort as a starting point for suitable interceptor missiles. Successful boost-phase intercept missiles, however, would have to be faster than the test missiles....

Using the modified SM-3 or wide-diameter missiles (fast-accelerating interceptors with high terminal speeds), the ship could be as far as 1,000 kilometers from the launch point. U.S. Navy ships thus equipped in international waters could engage missiles launched from all of North Korea or Iraq. The effectiveness of sea-based boost-phase missile interceptors against ICBMs launched from Iran would depend on the part of the country from which the ICBMs were launched. In some cases, U.S. forces would need ground-based or airborne supplements.

⁴³ Due to an apparent production error, the article as published in original form mistakenly identified the missile being referred to at this point as the SM-1, which is a very old version of the Standard missile that has no potential for missile defense. When the article was reprinted later by a different publication, the reference was corrected to refer to the SM-2 Block IV, which is a new version of the Standard missile intended for intercepting aircraft and cruise missiles.

A sea-based boost-phase capability has clear political advantages and some disadvantages. Its main advantage is the ability to provide a potential defense against ICBMs launched from North Korea and most parts of the Middle East. At the same time, sea basing would present no threat to Russia's and China's land-based ICBM deterrents because those launch points are far inland.

As for disadvantages, a sea-based boost-phase system would potentially threaten Russia's submarine-launched deterrent, assuming a capability existed to estimate the general location of the submarine. Second, any boost-phase defenses would require the establishment of a "no-launch zone" or other special procedures over the rogue state and a willingness in extremis to delegate the engagement decision to the local U.S. commander. Both requirements may be difficult to sustain politically. Finally, any boost-phase concept would require launching the interceptors in the direction of the country launching the ICBMs as well as toward third parties that may not be involved. For example, launches against North Korean missiles with boost-phase missile interceptors would entail launches on azimuths toward both North Korea and China. When defending against Iraqi and Iranian missile launches, the boost-phase missile interceptors would fly over several countries on an azimuth toward Russia. Additionally, debris from the engagement (damaged warheads, spent interceptor boosters, and so forth) could have an impact on uninvolved countries.

If the United States accepts these political disadvantages, the operational advantages of a sea-based boost-phase interceptor are significant. With the potential exception of Iran, these interceptors are most effective against the countries in need of dissuasion and deterrence, and they are less effective against former adversaries that need reassurance.⁴⁴

MDA Director Kadish stated in July 2001 that the Sea-Based Boost program "is considering a high-speed, high-acceleration booster coupled with a boost kill vehicle. This same booster will be evaluated (with a different kill vehicle) for sea-based midcourse roles."⁴⁵ The program could be pursued as either a complement to air- and space-based boost-defense systems or a hedge against the possibility of technical problems in these other programs. General Kadish also stated in July 2001 that MDA is "going to institute concept studies and [is] looking at concepts on how to do the boost phase with kinetic energy, as a hedge against the directed energy, should we run into problems there. So we have some experiments in space with the space-based laser, and we're looking at whether we should be doing some experiments in space with kinetic energy that build on the terrestrial side for airborne laser and a sea-based kinetic energy killer."⁴⁶

In May 2002 it was reported that

⁴⁴ Hans Binnendijk and George Stewart, "Toward Missile Defenses from the Sea," *Washington Quarterly*, Summer 2002: 199-200. The article was later reprinted (with slight changes) under the same title in the June 2002 of *Defense Horizons*, a publication of the Center for Technology and National Security Policy of the National Defense University.

⁴⁵ Statement of Lieutenant General Ronald T. Kadish, USAF, Director, Ballistic Missile Defense Organization, on The Ballistic Missile Defense Program, Amended Fiscal Year 2002 Budget, Before the Senate Armed Services Committee, July 12, 2001, page 26.

⁴⁶ Transcript of July 13, 2001, DOD news briefing on missile defense with Lt. Gen. Kadish.

A modified Standard Missile-3 using a new kinetic kill vehicle now being developed by the Missile Defense Agency may be included in a series of experiments planned for fiscal year 2004 that will look at promising new approaches to defeat ballistic missiles during their boost phase, an MDA spokesman told *Inside the Navy* last week. MDA plans to spend over \$2 billion through FY-07 to develop a boost-phase interceptor that could be launched from a Navy ship, according to agency budget documents....

MDA spokesman Christopher Taylor told ITN that during FY-02 the agency and the Navy will develop mission requirements for early critical experiments (ECE) scheduled for FY-04. "Current options for the ECE missile include a modified Standard Missile-3 that incorporates the new Generation 1 boost kill vehicle under development as well as other more powerful boosters resulting from MDA's Broad Agency Announcement," he said.

The Navy and MDA will also finish a concept definition and assessment study in FY-02 that looks at candidate kinetic energy boost elements of the Ballistic Missile Defense System, the layers, multiprogram architecture that will handle a whole range of ballistic missile threats from ICBMs to the very shortest range missiles.

"This study, done in collaboration with the Missile Defense National Team, is assessing a broad range of boost concepts spanning the complete set of basing modes including sea, space, air and ground," Taylor said. "Our intent is to execute critical experiments in FY-03-05 to mitigate the risk in accomplishing the boost mission. These critical experiments may culminate in a focused demonstration of a particular basing mode depending on the results of the CD&A study and the early critical experiments."⁴⁷

In early September 2002, it was reported that the Defense Science Board (a federal advisory committee that provides independent advice to the Secretary of Defense) had recommended in August 2002 that DOD focus its missile defense efforts on two main approaches: a ground-based midcourse system and a sea-based boost and ascent-phase system.⁴⁸

In June 2002, it was reported that one

boost-phase activity that's materializing involves modifying the lightweight exoatmospheric projectile (Leap) used as the kill vehicle in the sea-based midcourse defense system. It will gather data on a boosting target, according to Dean T. Gehr, missile defense business development manager for Raytheon. The goal is to conduct a flyby experiment and determine whether an infrared sensor can detect the missile. Leap's solid-fuel divert and attitude control system (DACS) would likely be replaced with a larger, liquid fuel system that would give the kill vehicle more maneuverability.

⁴⁷ Thomas Duffy, "Study to Define Candidates for Sea-Based Boost-Phase Interceptor," *Inside the Navy*, May 20, 2002.

⁴⁸ Bradley Graham, "Missile Defense Choice Sought," *Washington Post*, September 3, 2002: 1.

While the boosting missile is easy to spot because of its large infrared signature, the weapon becomes encased in a plume of hot gases as it reaches higher altitude and thinner atmosphere. The seeker then has difficulty finding the missile. Modifications will likely be made to the IR sensor to look at the bright target, Gehr said. If the IR sensor alone can't do the job, it might have to be supplemented with an ultraviolet sensor or laser radar.

For test purposes, the data-collection effort probably will use the Standard Missile SM-3, which is the interceptor for the sea-based midcourse system. Raytheon hopes a modified SM-3, with a 21-in. second stage, can serve as the interceptor in an operational configuration, but MDA officials have indicated they may need a dedicated missile. Notional performance for such a system would be 30g acceleration and speeds of 8 km./sec. velocity at burnout.⁴⁹

In October 2002 it was reported that

DOD and industry officials say [MDA] is leaning toward developing a 'multi-use' boost-phase interceptor with a speed of around 6km/s [6 kps] that could be launched from navy ships, but could also be operated from land, even airborne and potentially have space applications.

"We have initiated experiments this year to demonstrate the capabilities of a kinetic-energy boost system," said Pat Sanders, program executive officer for the MDA's overarching BMDS [Ballistic Missile Defense System]. "We expect to conduct tests to intercept a boosting missile no later than 2005." Later, the same interceptor booster may be evaluated with a different kill vehicle for mid-course use, DOD officials said.⁵⁰

Midcourse Defense Segment

Steven A. Hildreth, Specialist in National Defense

Ground-Based Midcourse. The Ground-Based Midcourse Program, also known previously as the National Missile Defense (NMD) program, would use some number of ground-based interceptors to seek to defend all 50 states of the United States from a limited intercontinental-range ballistic missile attack. The kinetic kill warhead on the missile would seek to destroy its intended target through direct collision during the midcourse phase of the attacking missile or warhead. Major subsystems might include some number of existing and new radars and surveillance platforms, including the Aegis Spy-1 radar, existing early warning radars and a new X-Band radar, the space-based Defense Support Program, SBIRS (High and Low), and various Battle Management, Command, Control, and Communications (BMC³) components.

Pacific Missile Defense Testbed. The Administration has moved forward with the Pacific Missile Defense Testbed (also known as the Midcourse Test Bed).

⁴⁹ Robert Wall, "Pentagon Eyes Additions To Anti-Missile Arsenal," *Aviation Week & Space Technology*, June 10, 2002: 20.

⁵⁰ Michael Sirak, "Sea-Based Ballistic Missile Defence: The 'Standard' Response," *Jane's Defence Weekly*, October 30, 2002.

The Administration asserts this Test Bed could provide a rudimentary ground-based ICBM defense contingency capability.

In December 2002, the Administration announced a specific program and timeline. The Administration said the United States would begin fielding initial missile defense capabilities in 2004-2005 to meet the near-term ballistic missile threats to the U.S. homeland, to U.S. deployed forces, and to counter ballistic missile threats to U.S. friends and allies. This initial capability would build on the planned Pacific Missile Defense Testbed and would serve as a starting point for deploying increasingly effective missile defenses over time, according to the Administration.

The initial set of capabilities in mind for 2004-2005 include

- up to 20 ground-based interceptors designed to intercept and destroy ICBMs during the midcourse phase of their flight. These interceptors would be based at Ft. Greeley, Alaska (16 interceptors) and Vandenberg Air Force Base, California (four interceptors);
- up to 20 sea-based interceptors deployed on existing Aegis ships to try and intercept ballistic missiles in the first few minutes after they are launched (i.e., during their boost and ascent phases of flight);
- deployment of air-transportable PAC-3 systems designed to intercept short and medium-range ballistic missiles; and
- land, sea, and space-based sensors, including existing early warning satellites, an upgraded radar now located at Shemya, Alaska, a new sea-based X-band radar, upgraded existing early warning radars in the UK and Greenland, and use of other sensors now on Aegis cruisers and destroyers.

These capabilities could be improved upon through additional measures such as additional interceptors of varying capabilities and basing platforms. Ground was broken for the Ft. Greely site on June 5, 2002, for missile silos and support buildings. The initial ground-based midcourse parts of the testbed are to be constructed by the end of September 2004. The purpose of the test bed is to validate the ground-based midcourse concept and to improve the realism of interceptor tests, according to DOD. Other key parts of the testbed are planned or are under construction in Alaska, California, Colorado, the Republic of the Marshall Islands.

Costs. System costs have not been provided. These costs may also not become available because of the evolutionary acquisition strategy adopted for missile defense. Nonetheless, there is a useful point of reference in terms of costing a midcourse system. The Clinton Administration considered deploying a system of 100 ground-based interceptors in Alaska at a cost of about \$36 billion (the life-cycle cost was estimated to be about \$44.5 billion through FY2026). The Initial Operational Capability (IOC) for this system was 2005.

Recent Tests and Technical Challenges. The NMD or ground-based midcourse program has witnessed a number of technical challenges. These include ongoing delays in testing the rocket booster, which in turn has adversely affected decisions on acquiring long-lead interceptor technologies. In addition, modeling and simulation tools that were supposed to aid the Clinton Administration in its decision

whether to deploy a limited NMD in Alaska, were delivered too late to help in that decision. The Integrated Flight Test (IFT) program also has experienced uncertain results. Although many tests were called successful by the DOD, several post-intercept test analyses have been considered more ambiguous. Much of this debate centers over the degree to which target missiles or warheads were artificially enhanced to make the intercept more likely. Program delays have occurred regularly. But, a great number of IFT objectives were designed to test other aspects of the missile launch, missile flight, and interceptor performance. These other, non-intercept objectives have largely been considered successful.

On December 11, 2002, the Missile Defense Agency announced it could not complete a planned intercept test because the kill vehicle and the booster rocket failed to separate. This was the 8th intercept of the ground-based midcourse research and development program. The first test on October 3, 1999, successfully intercepted its intended target. The 2nd test occurred on January 19, 2000; an intercept was not achieved because of a problem with the on-board cooling system. The 3rd test on July 8, 2000, also failed to intercept its target because the kill vehicle failed to separate from the booster rocket. The 4th test, on July 14, 2001, successfully intercepted its target, as did the 5th and 6th tests on December 3, 2001 and March 15, 2002, respectively. BMDO stated this test is a major step in an “aggressive test program,” and that it was the “third successful intercept test in five attempts.” The 7th test on October 14, 2002 was also deemed a success and for the first time a ship-based SPY-1 radar was used to track a long-range target.

More recent planned intercept flight tests have been delayed for some time. Currently, the BMD interceptors deployed in Alaska have not been tested in their current configuration (i.e., current booster and interceptor). Hence, questions are raised over its performance and effectiveness.

Sea-Based Midcourse. *(Ronald O’Rourke, Specialist in National Defense)*

Ships and SM-3 Interceptor. The Sea-Based Midcourse program is the successor to the Navy Theater-Wide (NTW) program (which was also called the Navy Upper Tier program). MDA Director Kadish stated in his July 2001 testimony to Congress on the Administration’s new missile defense program that “The Sea-Based Midcourse System is intended to intercept hostile missiles in the ascent phase of midcourse flight, which when accompanied by [the] ground-based system, provides a complete midcourse layer [of defense]. By engaging missiles in early ascent, sea-based systems also offer the opportunity to reduce the overall BMD System’s susceptibility to countermeasures.”⁵¹

MDA plans to spend about \$3.3 billion on the Sea-Based Midcourse program between FY2003 and FY2007. Major contractors for the program include Raytheon Missile Systems of Tucson, Arizona (the prime contractor for the development of the interceptor missile), and Lockheed Martin Naval Electronic and Surveillance Systems

⁵¹ Statement of Lieutenant General Ronald T. Kadish, USAF, Director, Ballistic Missile Defense Organization, on The Ballistic Missile Defense Program, Amended Fiscal Year 2002 Budget, Before the Senate Armed Services Committee, July 12, 2001, page 24.

of Moorestown, New Jersey (which manages the development of the shipboard Aegis Weapon System).

The Sea-Based Midcourse system, like the earlier NTW program, would be based on the Navy's Aegis ships, which are equipped with the powerful SPY-1 radar.⁵² The Navy's NTW program was designed to intercept theater-range ballistic missiles during the midcourse phase of flight, so as to provide theater-wide (i.e., regional) defense of U.S. and friendly forces, vital military and political assets ashore, and large geographic areas. Achieving a capability against theater-range ballistic missiles involves modifying the SPY-1 radar to improve its ability to detect and track ballistic missiles and developing a new version of the Standard Missile interceptor known as the SM-3. Compared to the earlier SM-2 missile, the SM-3 would incorporate a third-stage rocket motor to give the missile a higher maximum speed (i.e., a higher "burn-out velocity"), and a kinetic kill vehicle (KKV) called the Lightweight Exo-Atmospheric Projectile (LEAP) that destroys the enemy missile by colliding with it.

MDA Director Kadish's July 2001 testimony and subsequent statements suggest that the Administration's plan for Sea-Based Midcourse is to proceed with development and deployment of the capability envisaged under the NTW program, and then work toward improving the system so that it can eventually be used against faster-flying intercontinental ballistic missiles (ICBMs). MDA officials have indicated that if developmental testing goes well, the basic version of the Sea-Based Midcourse system (the NTW-like version capable of intercepting theater-range ballistic missiles) might be ready for deployment in 2005 or 2006. A more advanced version of the Sea-Based Midcourse system (a version capable of intercepting ICBMs) might be ready for deployment several years after that.

The basic version of the Sea-Based Midcourse system was successfully tested three consecutive times in 2002, achieving intercepts on Aries target ballistic missiles on January 25, June 13, and November 21. The June intercept occurred on the day that the ABM treaty expired and was the first to employ a sea-based Aegis radar to guide the interceptor to the target missile. Both the January and June tests involved descent-phase intercepts. Following the successful result of the June test, the flight test program was accelerated with the intention of deploying the system as a near-term defense against theater-range ballistic missiles in 2005 or 2006. The November test was the first in a series of six flight tests aimed at this goal, and was the first in which the Sea-Based Midcourse system intercepted a missile in its ascent phase. The remaining five tests in the series will involve more complex and stressing engagement scenarios. Three of these five tests are planned for 2003. The first may occur in April or May and the second in August; both are to involve ascent-phase intercepts. The tests will also explore the potential for the SM-3 to intercept ballistic

⁵² Aegis ships are cruisers and destroyers equipped with the Aegis air defense system, the Navy's most capable surface-ship air-defense system. The Aegis system is a highly integrated combination of sensors (including the SPY-1 phased array radar, which is unique to Aegis ships), computers, software, displays, weapon launchers and weapons. The Navy's Aegis ships are the Ticonderoga (CG-47) class cruisers and Arleigh Burke (DDG-51) class destroyers.

missiles at lower altitudes in space, so that it can perform part of the mission that was to be performed by the now-cancelled Navy Area Defense (i.e., Lower Tier) program (see discussion in the Sea-Based Boost section).⁵³

Improving the Sea-Based Midcourse system so that it can be used against ICBMs would likely involve making additional modifications to the Aegis ships' radars, including further improvements to the SPY-1 radar, which operates in the S band, and the potential addition of a new X-band shipboard radar called the high-power discriminator.

Improving the Sea-Based Midcourse system so that it can be used against ICBMs would also involve developing a larger and higher-speed missile than the SM-3, which has a maximum speed (i.e., burn-out velocity) of a bit more than 3 kilometers per second (kps). The Navy reportedly has been considering 3 different options for a higher-speed missile:⁵⁴

- **Faster SM-3.** This missile, also referred to as the SM-3 Block 1 or the Enhanced NTW missile, would extend the 21-inch diameter of the SM-3's first-stage booster up through the second stage, but retain the Standard Missile's original 13.5-inch diameter above that point. It would have a range of 1,000 kilometers and a maximum speed of 4.5 kps, and it would carry an improved version of the NTW missile's LEAP KKV weighing about 30 kilograms.
- **Enhanced SM-3.** This missile, also referred to as the SM-3 Block 2 or the Improved 8-Pack missile, would increase the diameter of the Standard missile along its entire length to 21 inches — the maximum diameter that can be fired from the Mk 41 vertical launch system (VLS) installed on Aegis ships. (The Mk 41 VLS is installed on Navy ships in modules that each contain 8 missile-launch tubes, leading to the use of the term 8-pack.) This missile would have a range of 1,500 kilometers and a maximum speed of 5.5 kps, and it would carry a more capable KKV weighing about 40 kilograms.

⁵³ "Sea-Based Ballistic Missile Defense Test Successful," *Navy News Service*, November 22, 2002; Marc Selinger, "Sea-Based Midcourse System Intercepts First Ascending Target," *Aerospace Daily*, November 25, 2002; Thomas Duffy, "Navy Scores Third Straight Ballistic Missile Intercept During Hawaii Test," *Inside the Navy*, November 25, 2002; Michael Sirak, "Sea-Based Ballistic Missile Defence: The 'Standard' Response," *Jane's Defence Weekly*, October 30, 2002.

⁵⁴ Sources for information on missile options: Gopal Ratnam, "U.S. Navy To Play Larger Role In Missile Defense," *Defense News*, January 21-27, 2002: 10; Robert Holzer, "U.S. Navy Seeks Larger Share of Antimissile Funds," *Defense News*, April 9, 2001: 1, 44 (graphic on page 1); Michael C. Sirak, "White House Decision May Move Sea-Based NMD Into Spotlight," *Inside Missile Defense*, September 6, 2000: 1; Robert Holzer, "DOD Weighs Navy Interceptor Options," *Defense News*, July 24, 2000: 1, 60 (graphic on page 1); Robert Holzer, "U.S. Navy Gathers Strength, Allies in NMD Showdown," *Defense News*, March 15, 1999: 1, 42 (graphic on page 1).

- **New Missile.** This missile, also referred to as the Standard Missile 27 or the 6-Pack missile, would have a diameter of 27 inches and a longer length than the Standard Missile, and would be fired from a new VLS designed to accommodate missiles of that diameter and length. This new VLS could have 6 missile-launch-tube modules occupying the same deck area as the 8-tube modules of the current Mk 41 VLS, leading to the use of the term 6-pack. This missile would have a range of more than 1,500 kilometers and a maximum speed of 6.5 kps, and it would carry an even more capable KKV, either the same KKV being developed for the land-based NMD system or an advanced-technology KKV, weighing about 50 kilograms.

In addition to the above missile options, Japan is participating in a cooperative development program with MDA to develop certain technologies that could be used to improve the SM-3.⁵⁵

A higher-speed missile developed for an improved Sea-Based Midcourse system might prove suitable, with a different kill vehicle, for use as an interceptor for a Sea-Based Boost system. Conversely, a higher-speed missile developed for the Sea-Based Boost program might prove suitable, with a different kill vehicle, for use as the interceptor for an improved Sea-Based Midcourse system. (See section on the Sea-Based Boost program.) Using the same basic interceptor missile for both programs could reduce total sea-based missile defense costs.

Sea-Based X-Band Radar. Independent of the Aegis-ship program described above, MDA announced on August 1, 2002 that it wants to build a large, sea-based, X-band missile tracking and engagement radar to support the Ground-Based Midcourse system. This sea-based radar would be built in lieu of a ground-based X-band missile defense radar. MDA wants the sea-based radar to be deployed by September 2005 as part of the Pacific missile defense development test bed. The sea-based radar option was selected over the alternative of building an additional ground-based X-band radar in large part because the ability to reposition a sea-based radar permits the creation of a numerous radar configurations that can support a variety of missile-defense development tests and emerging missile defense requirements. Boeing and Raytheon are main contractors for the radar, whose total

⁵⁵ For more on Japan's role in ballistic missile defense, see CRS Report RL31337, *Japan-U.S. Cooperation on Ballistic Missile Defense: Issues and Prospects*, by Richard P. Cronin.

acquisition has been estimated at about \$900 million.⁵⁶ No funds specifically for the sea-based X-band radar were included in the FY2003 defense budget request.

Under MDA's plans, the X-band radar is to be carried aboard "a modified, fifth generation semi-submersible platform similar to those currently used in the oil exploration industry." The platform would have a length of 390 feet, a beam (width) of 238 feet, and a draft of 77 feet. It would displace 50,000 tons, which is about half the full load displacement of a U.S. Navy Nimitz-class aircraft carrier. It would have a deck area measuring 270 feet by 230 feet and would be able to relocate itself using electric thrusters. The X-band radar would sit on the deck, encased in a spherical shell.⁵⁷ The general concept of deploying large radars on sea-based platforms is not new: The United States over the years has outfitted and operated several merchant-type ships with large radars similar to MDA's proposed X-band radar to support flight tests of U.S. ballistic missiles and reportedly to learn about the characteristics of foreign ballistic missiles.

Terminal Defense Segment

Ground-Based Terminal. (*Steven A. Hildreth, Specialist in National Defense*)

Patriot PAC-3. The Patriot PAC-3 (Patriot Advanced Capability-3, MIM-104 Patriot/ERINT) is the U.S. Army's primary medium-range air defense missile system and is considered a major system improvement over the Patriot used in the Gulf War, and of the subsequent PAC-2. It will target enemy short- and medium-range missiles in their mid-course or descent phase in the lower atmosphere, and will be used in conjunction with the longer-range THAAD. When all changes have been made, the PAC-3 will have a new hit-to-kill interceptor missile (the ERINT), improved communications, radar, and ground support systems. The first unit to be equipped with the final version is receive PAC-3 missiles in late 2001 at Fort Bliss, Texas. Full-rate production was scheduled to begin in late 2001, but slipped to late 2002.

In April 2000, the Pentagon projected costs of PAC-3 had increased by \$102 million to \$2.9 billion because of increased reliability and spares costs. A GAO

⁵⁶ Michael Sirak, "Sea-Based Ballistic Missile Defence: The 'Standard' Response," *Jane's Defence Weekly*, October 30, 2002; Kerry Gildea, "New Sea-Based Missile Defense Radar Passes Critical Design Review," *Defense Daily*, October 24, 2002; Marc Selinger, "MDA Plans for Sea-Based X-Band Radar Hit Snag With Congress," *Aerospace Daily*, October 11, 2002; Kerry Gildea, "MDA Lays Out Phased Plan To Get New Radar Into Testing In 2005," *Defense Daily*, August 6, 2002: 1; Sharon Weinberger, "MDA Chooses Sea-Based Radar for Missile Defense," *Aerospace Daily*, August 5, 2002; Kerry Gildea, "MDA Awards Boeing \$33 Million To Start Work on Sea-Based X-Band Radar," *Defense Daily*, August 5, 2002.

⁵⁷ Thomas Duffy and Christopher J. Castelli, "Appropriators Cast Wary Eye on Sea-Based X-Band Radar Initiative," *Inside the Navy*, October 21, 2002. The article states that the quoted passage and the other information on the platform for carrying the X-band radar was taken from a summary of the sea-based X-band radar program provided by the Navy to *Inside the Navy*.

report issued in July 2000 showed PAC-3 total program costs increased from \$3.9 billion for 1,200 missiles planned in 1994 to \$6.9 billion for about 1,012 missiles in the current plan. In April 2001, BMDO estimated the PAC-3 acquisition costs to be \$10.1 billion. BMDO and the Army are attempting to cut the current cost of the missile to allow the purchase of additional missiles. In December 2000, the Army announced it had restructured the program to finish testing and begin full-rate production earlier. It also plans to increase the numbers purchased in the years 2003-2007. For FY2002, the Bush Administration requested \$784 million for PAC-3, a 76% increase over the amounts requested and approved for FY2001. The Administration also transferred funding for the PAC-3 from BMDO to the Army. The House Armed Services Committee, in its version of the FY2002 Defense Authorization Bill did not approve this transfer; this too was later sustained in Congress.

Beginning in 1999, PAC-3 had a successful string of intercept flight tests destroying 10 of 11 targets, prior to a partial test failure in February 2002 (one PAC-2 missile intercepted a drone aircraft, while a second PAC-2 and a PAC-3 missile missed their intended targets). Subsequent successful intercepts occurred on March 21, April 25, and May 30, 2002.

A concern raised was the rising costs of PAC-3. It has been argued that unit costs could be reduced by increasing the number of units purchased and increasing the pace of production. If more countries buy PAC-3, and if the MEADS program is fielded with PAC-3 missiles, unit costs would be further reduced. (Germany, the Netherlands, Japan, Israel, and Taiwan have Patriot systems and are in various stages of upgrading them. South Korea is considering buying Patriots and Germany and Italy are participating in MEADS, which would use Patriot missiles.)

In May 2000, DOD decided to stop development of PACM (designed to defeat cruise missiles) because PAC-3 and improvements being made to PAC-2 systems provide a more cost effective defense against ballistic and cruise missile threats. The decision has been controversial, particularly among companies that would have produced PACM. But the conference report on the FY2001 authorization bill noted no funds had been requested for PACM and instructed the Secretary of Defense to determine if PACM production is warranted.

The effectiveness of PAC-3, and other missile defenses, against countermeasures is also an issue. Russia has developed a guided warhead for the Scud missile that it claims has an accuracy of 10-20 meters, can defeat Patriot missile defenses, and is immune to jamming and electronic countermeasures. It was reported in March 2001 that Russia is offering this warhead for sale to a number of countries in the Middle East that have Scud missiles.

Theater High Altitude Area Defense (THAAD). The THAAD program is the U.S. Army's weapon system designed to destroy non-strategic ballistic missiles just before they reenter the atmosphere or in the upper atmosphere. The THAAD missile would use a single-stage, solid propellant rocket and a hit-to-kill interceptor designed to destroy the attacking missile with the kinetic energy of impact. Unlike lower-tier, shorter range systems, such as the Patriot PAC-3 and MEADS, THAAD

is intended to help protect wider areas against missiles and falling debris of missiles, as well as possible nuclear, biological, or chemical materials.

In April 2000, the Pentagon released a Selected Acquisition Report stating the projected costs of THAAD had increased by \$898 million to a total of \$9.5 billion because of a revised estimating methodology. In April 2001, BMDO estimated THAAD acquisition costs to be \$16.8 billion, and the life cycle costs to be \$23 billion.

THAAD entered the Engineering and Manufacturing Development (EMD) phase in late June 2000. A more advanced version designed to defeat attacking missiles employing countermeasures was scheduled for 2011. In an accelerated development proposal the Army considered in 2000, the first THAAD unit equipped could be moved from FY2007 to FY2006. The Department of Defense is still studying this accelerated option. Simultaneously, DOD is relaxing the requirement that THAAD be able to intercept targets within and outside the atmosphere, raising the altitude at which it must be able to conduct an intercept. The minimum intercept altitude had been 40 kilometers.

Earlier technological problems in THAAD's development jeopardized support for the system. But on June 10, 1999, after THAAD had failed in six previous interceptor flight tests, the first success was achieved. In each of those six previous unsuccessful intercept flight tests, a different subsystem had failed. On August 2, 1999, a second THAAD missile successfully intercepted a target missile.

After the second successful intercept, Lockheed Martin submitted a proposal for moving THAAD in EMD, but the Army Space and Missile Defense Command rejected the proposal in April 2000 because of management and testing plan deficiencies. Lockheed Martin addressed these problems, and the Army later recommended the Defense Acquisition Board (DAB) begin its review of THAAD advancing to EMD.

Because of concerns that the THAAD and NTW programs were not being tested against target missiles with the speed and other characteristics of likely enemy missiles (such as the North Korean Taep'o-dong 1), Representative Vitter introduced legislation in 1999 (H.R. 2596) that would have required BMDO to make appropriate program management and technology adjustments in the NTW and THAAD programs. Similar legislation in the 107th Congress, such as H.R. 1282, was designed to help NTW and THAAD improve their likelihood of successful intercepts against more realistic test targets.

For FY2002, the Bush Administration requested \$922 million for THAAD, which was a 68% increase over the amount requested and appropriated for FY2001 (\$549.9 million), and a 32% increase over the amount requested for FY2002 by the outgoing Clinton Administration. Congress cut THAAD funding by \$50 million for FY2002. This cut was directed at denying the Administration's request to acquire a limited number of THAAD contingency missiles. The FY2003 request for THAAD is \$935 million.

Medium Extended Air Defense System (MEADS). The Medium Extended Air Defense System (MEADS), is a multinational, ground-based, mobile, air and missile defense system. It is essentially a composite of existing technologies with either similar or enhanced capabilities. It will cover the lower-tier of the layered air and theater missile defense and will operate in the division area of the battlefield to protect against various airborne threats. Distinguishing characteristics of MEADS are its stated ability to maneuver and deploy quickly and to provide 360-degree coverage. It will be able to accompany troops within the theater and will require less manpower and logistical support to operate than other missile defense systems. MEADS will use the Patriot PAC-3 missile with its hit-to-kill warhead, designed to intercept multiple and simultaneous short range ballistic missiles (SRBMs), low cross-section cruise missiles and aircraft, and unmanned aerial vehicles. MEADS will eventually replace the aging HAWK air defense system. In addition to fulfilling operational requirements for limited air defense, the program is also expected to reinforce interoperability of NATO forces and to reduce the U.S. burden of cost for helping to maintain European defense.

BMDO has been responsible for program direction and system architecture and integration. The Pentagon sought to shift the management of MEADS and PAC-3 to the Army from BMDO. Some question whether the Army will give the program sufficient budget priority to sustain development. The House Armed Services Committee did not approve this transfer in its version of the FY2002 Defense Authorization Bill, and this was upheld by Congress.

Under the initial May 1996 Memorandum of Understanding, Germany and Italy committed to fund 25 percent and 15 percent of the program, respectively, for the next 10 years. The German military has questioned the number of MEADS units it would need and whether it could afford them, the German Parliament balked at approving its share of development costs, and the German government then asked to have the program restructured to reduce its \$22 billion cost, even if that required reduced capability. In July 2001, the NATO MEADS Management Agency granted a three-year, \$216 million risk reduction contract to MEADS International (a team consisting of Lockheed Martin, Alenia Marconi, and the European Aeronautic Defence and Space Company). The United States will pay 55 percent of the risk reduction program, Germany 28 percent, and Italy 17 percent. The agreement was modified to divide German funding and commitment into three phases to ease the Defense Ministry's negotiations with Parliament. Germany has also decided to stop upgrading its Patriot batteries until it can determine whether MEADS will duplicate Patriot's capabilities. The definition phase of development has been extended three years thus putting deployment off till 2009.

Responding to congressional criticism of the program's costs for FY2001, Pentagon officials suggested that Germany and Italy coproduce the Patriot PAC-3 interceptor for incorporation into MEADS. In April 2000 it was reported that Germany and Italy had tentatively agreed to use the Patriot rather than a new interceptor, but still plan to develop a new seeker radar.

For FY2002, the Administration requested \$74 million for development of MEADS, \$20 million more than was appropriated for FY2001 (the defense

authorization act for FY2001 decreased the requested amount by \$9.7 million.) In the final appropriations bill, funding for MEADS was cut slightly.

The Lockheed-Martin Corp. and the Hughes Aircraft and Raytheon Company consortium represented the U.S. partners of two competing international teams. Alenia of Italy, and European Aeronautic Defence and Space Company (formerly Daimler-Chrysler Aerospace) of Germany, represent the European group. In May 1999, the three governments selected the team headed by Lockheed Martin to develop MEADS. Target production and fielding dates were set for 2006 but have slipped to 2009.

In May 1996, France rescinded its initial commitment to fund 20 percent of the MEADS program. Despite budgetary constraints, however, France is still interested in developing missile defenses, perhaps an indigenous system. The United Kingdom is not a participant in the program and to date has taken no official position on it. The Netherlands and Turkey have also considered participating in the joint endeavor.

Sea-Based Terminal. (*Ronald O'Rourke, Specialist in National Defense*) The sea-based terminal effort has undergone a number of recent changes. These are described below.

Cancellation of NAD Program. On December 14, 2001, DOD announced that it had canceled the Navy Area Defense (NAD) program, the program that was being pursued as the Sea-Based Terminal portion of the Administration's overall missile-defense effort. In announcing its decision, DOD cited poor performance, significant cost overruns, and substantial development delays.⁵⁸ DOD stated that the program's unit acquisition and unit procurement costs had risen 57 percent and 65 percent, respectively.⁵⁹

⁵⁸ The NAD program, also sometimes called the Navy Lower Tier program, was initiated several years ago. Prior to DOD's December 14, 2001, cancellation announcement, the Bush Administration's plan was to maintain the mission and system configuration of the NAD program as originally defined, but transfer the program from BMDO (now MDA) to the Navy on the grounds that the program was technically more mature and had evolved from an air defense mission.

The NAD program was to have been deployed on Navy Aegis ships and was designed to intercept short- and medium-range theater ballistic missiles in the final, or descent, phase of flight, so as to provide local-area defense of U.S. ships and friendly forces, ports, airfields, and other critical assets ashore. The program involved modifying both the Aegis ships' radar capabilities and the Standard SM-2 Block IV air-defense missile fired by Aegis ships. The missile, as modified, was called the Block IVA version. The modifications included a new, thrust-vector-controlled booster, a stronger airframe, the addition of a dual-mode radio frequency/infrared [RF/IR] guidance sensor, an improved blast-fragmentation (i.e., explosive) warhead, and enhancements to the missile's autopilot-control system. The system was designed to intercept descending missiles within the Earth's atmosphere (endo-atmospheric intercept) and destroy them with the Block IVA missile's blast-fragmentation warhead.

⁵⁹ Acquisition cost is the sum of procurement cost plus research, development, test and (continued...)

In announcing the cancellation, DOD cited the Nunn-McCurdy provision, a defense acquisition law passed in the 1980s. Under the law, a major defense acquisition program experiences what is called a Nunn-McCurdy unit cost breach when its projected unit cost increases by at least 15 percent. If the increase reaches 25 percent, the Secretary of Defense, to permit the program to continue, must certify that the program is essential to national security, that there are no alternatives to the program that would provide equal or greater military capability at less cost, that new estimates of the program's unit acquisition cost or unit procurement cost appear reasonable, and that the management structure for the program is adequate to control the program's unit acquisition or unit procurement cost.

Edward C. "Pete" Aldridge, the Under Secretary of Defense for Acquisition, Technology and Logistics — the Pentagon's chief acquisition executive — concluded, after examining the NAD program, that he could not recommend to Secretary of Defense Donald Rumsfeld that he make such a certification. Rumsfeld accepted Aldridge's recommendation and declined to issue the certification, triggering the program's cancellation. This was the first defense acquisition program that DOD officials could recall having been canceled as a result of a decision to not certify under a Nunn-McCurdy unit cost breach.⁶⁰

DOD stated that the cancellation of the program would "result in a work stoppage at some government and contractor facilities." Major contractors for the NAD program were Raytheon of Tucson, AZ, Lockheed Martin of Moorestown, N.J. and Middle River, MD, United Defense of Baltimore, MD, and Minneapolis, MN, Orbital Sciences of Dulles, VA and Chandler, AZ, and L-3 Communications of New York, NY. Major government field activities involved in the program were the Naval Surface Warfare Center (NSWC) at Dahlgren, VA, NSWC at Port Hueneme, CA, the Applied Physics Laboratory of Johns Hopkins University of Laurel, MD, and Lincoln Laboratories of the Massachusetts Institute of Technology of Lexington, MA.

Regarding termination costs for the NAD program, it was reported in early November 2002 that

The Defense Department has granted Raytheon a three-month extension for submitting a formal proposal for termination costs tied to one of two contracts the company held under the canceled Navy Area missile defense program, according to a company spokeswoman and a DOD official....

At the time of the cancellation, Raytheon held two contracts — one for low-rate initial production [LRIP] and one for the engineering and manufacturing development [EMD] phase of the program. Under federal acquisition regulations, a contractor has one year from contract termination to submit a final termination proposal, the DOD official said. Raytheon was formally notified of the Area

⁵⁹ (...continued)
evaluation (RDT&E) cost.

⁶⁰ "Navy Area Missile Defense Program Cancelled," Department of Defense News Release No. 637-01, December 14, 2001; James Dao, "Navy Missile Defense Plan Is Canceled By the Pentagon," *New York Times*, December 16, 2001; Gopal Ratnam, "Raytheon Chief Asks DOD To Revive Navy Program," *Defense News*, January 14-20, 2002: 10.

program's contract termination in January 2002 and the final settlement proposal would normally be received by January 2003, he said.

But Raytheon asked for the extension on the EMD contract "due to the large number of complex subcontracts associated with vendor parts on Standard Missile-2 Blk IVA," Raytheon spokeswoman Sara Hammond told *Inside the Navy* last week. The SM-2 Blk IVA missile carried the interceptor warhead the Navy was going to use for the Area program.

"As such, Raytheon expects to submit the LRIP proposal in January and the EMD contract in April 2003," Hammond said. The DOD official said that after the department receives Raytheon's final proposal, there would "be a period of negotiation, normally several months, until final settlement is reached."

At the time of the cancellation, sister publication *Inside Missile Defense* reported the Navy had estimated termination costs for Raytheon to be slightly more than \$200 million. That breaks down to \$106.9 million for the EMD contract and \$95.3 million for the LRIP contract, according to the Navy figures. Both of those contracts were tied to the SM-2 Blk IVA development.⁶¹

Post-Cancellation Strategy. Following cancellation of the program, DOD officials stated that the requirement for a sea-based terminal system remained intact. This led some observers to believe that a replacement sea-based terminal defense program might be initiated. In May 2002, DOD announced that instead of starting a replacement program, MDA had instead decided on a two-part strategy to (1) modify the SM-3 missile to be used in the sea-based midcourse program to intercept ballistic missiles at lower altitude, and (2) modify the SM-2 Block 4 air defense missile (i.e., a missile designed to shoot down aircraft and cruise missiles) to cover some of the remaining portion of the sea-based terminal defense requirement. DOD officials said the two modified missiles could together provide much of the capability that was to have been provided by the NAD program. One aim of the modification strategy, DOD officials suggested, was to avoid the added costs to the missile defense program of starting a replacement sea-based terminal defense program.⁶²

In June 2002, it was reported that engineers are "grappling with" the issue of

how to adapt the SM-3 to attack shorter range (100-300-km.) targets. Since the demise of the Navy Area Wide project that was designed for Scud-like targets, the Pentagon has looked for solutions to bridge the gap. One option is to have SM-3 take on part of the mission. To engage targets at shorter ranges, SM-3 would be modified so the missile has the flexibility not to fire its two-pulse third stage, or fire just the first of two pulses. The goal is to be able to intercept the target near its apogee, outside the atmosphere where Leap⁶³ operates.

⁶¹ Thomas Duffy, "Raytheon Gets Extension For Area Defense Termination Proposal," *Inside the Navy*, November 4, 2002.

⁶² Gopal Ratnam, "U.S. Studies New Solution To Naval Missile Defense," *Defense News*, May 13-19, 2002: 4; Randy Woods, "DOD Scraps Navy Area Requirements, Will Expand Midcourse System," *Inside the Navy*, May 6, 2002.

⁶³ This is a reference to the Light Exoatmospheric Projectile, the SM-3's kill vehicle. This (continued...)

The Navy's Standard defense missile, the SM-2 Block 4, is viewed as another stopgap system, particularly for intercepting targets within the atmosphere. Testing will concentrate on three configurations — unmodified, software modifications to both the Aegis radar system and missile, and hardware and software changes.

Software adjustments being considered include adapting some of the [NAD] missile's autopilot and fuze modes to the SM-2 Block 4. The [NAD] interceptor, SM-2 Block 4A, had a high degree of commonality with the Block 4 air defense weapon.⁶⁴

In October 2002, it was reported that

Upon cancellation of the Navy Area program, the MDA commissioned industry and government teams to study successor options to the SM-2 Blk IVA. The teams found the most promising to be a modified Patriot Advanced Capability-3 missile with a booster and a program to modify the SM-2 Blk IV - which lacks the infra-red sensor of the [NAD program's] IVA model - to give it terminal BMD capabilities. Both options were envisaged as hit-to-kill systems, unlike the SM-2 family, which has blast-fragmentation warheads. Earlier this year the MDA said it intended to pursue the SM-2 Blk IV route and conduct tests to assess its ability to defeat short-range ballistic missiles "as high in the endo-atmosphere as possible through a combination of software and hardware modifications"....

Senior navy officials... continue to speak of the need for a sea-based terminal BMD capability "sooner rather than later" and have proposed a path to get there. "The cancellation of the Navy Area missile defence program left a huge hole in our developing basket of missile-defence capabilities," said Adm. [Michael] Mullen. "Cancelling the program didn't eliminate the warfighting requirement. "The nation, not just the navy, needs a sea-based area missile defence capability, not to protect our ships as much as to protect our forces ashore, airports and seaports of debarkation" and critical overseas infrastructure including protection of friends and allies.

The service intends to begin funding a next-generation anti-air warfare (AAW) interceptor in FY04, which it calls the 'Extended-Range Active Missile', to fill the air-defence gap left by the termination of the [NAD program's] SM-2 Blk IVA. It will have a range approaching 200nm.... Unlike the dual-mission SM-2 Blk IVA, the new missile will be configured solely for AAW. The navy, however, wants the design to allow for the easy evolution to a separate terminal-phase BMD variant. "Our hope is that we will create a product there, that while fulfilling our air-defence needs, makes it an option for them [the MDA] to leverage if they choose to do it," said Adm [Philip] Balisle. "They will have to

⁶³ (...continued)

kill vehicle was designed to work properly outside the atmosphere.

⁶⁴ Thomas Duffy, "Raytheon Gets Extension For Area Defense Termination Proposal," *Inside the Navy*, November 4, 2002.

make that decision in the context of the contribution to the [BMD] family of systems.”⁶⁵

Sensors Segment

Marcia S. Smith, Specialist in Aerospace & Telecommunications Policy

The sensors program element includes funding for the Space-Based Infrared System-Low (SBIRS-Low); the Russian-American Observation Satellite, or RAMOS (an international cooperative project to develop new missile early warning sensor technology); and program operations. For FY2003, the request was \$294 million for SBIRS-Low, \$69 million for RAMOS, and \$10 million for program operations, a total of \$373 million. In the FY2003 DOD appropriations and authorization acts, Congress approved the full \$294 million for SBIRS-Low and the \$10 million for operations. Regarding RAMOS, the authorization act cut the request by \$10 million, and the appropriations act cut it by \$26 million, although it also added \$7 million for RAMOS solar arrays.

Of these projects, SBIRS-Low is the most visible and controversial. It is one component of the Space Based InfraRed System (SBIRS), which is designed to replace and enhance the capabilities of existing satellites that provide early warning of missile launches. Historically, U.S. early warning satellites have been placed in geostationary orbit, high above the equator (22,300 miles). SBIRS also will use satellites in that orbit, as well in highly elliptical orbits, and in low orbits. Hence, the SBIRS program is divided into two components: SBIRS-High and SBIRS-Low. For more on both SBIRS-High and SBIRS-Low, see CRS Report RS21148, *Military Space Programs: Issues Concerning DOD's SBIRS and STSS Programs*, by Marcia S. Smith. SBIRS-High is managed by the Air Force and will not be discussed further here. Management of SBIRS-Low was moved from the Air Force to the Ballistic Missile Defense Office (now the Missile Defense Agency) effective October 1, 2001, to emphasize that its primary objective is to support missile defense.

The mission of SBIRS-Low⁶⁶ is to track missiles from launch to intercept or reentry; discriminate between targets and decoys; transmit data to boost, midcourse and terminal defense systems that will cue radars and provide intercept handovers; and provide data for intercept hit/kill assessments.

Because of deep concerns about the technological readiness of SBIRS-Low, and escalating cost projections, Congress appropriated no funding for SBIRS-Low in FY2002 (\$385 million had been requested). However, it appropriated \$250 million for “Satellite Sensor Technology” and gave the Secretary of Defense discretion as to whether the funding should be spent on SBIRS-Low or other technologies. The decision was to continue with a restructured SBIRS-Low program.

On April 15, MDA Director General Ronald Kadish submitted the restructuring plan to Congress. The SBIRS-Low design last year envisioned a system consisting

⁶⁵ Michael Sirak, “Sea-Based Ballistic Missile Defense: The ‘Standard’ Response,” *Jane’s Defence Weekly*, October 30, 2002.

⁶⁶ MDA, FY2003 RDT&E budget justification (R2-A Exhibit, Project 5041).

of between 20 and 30 satellites in low Earth orbit (the exact number had not been finalized). The first launch was projected for 2006. FY2003 DOD budget materials indicated that the launch would slip to 2008, but under the April 15 restructuring plan, two demonstration satellites will be launched beginning in FY2006 or FY2007. MDA is using its “spiral development” strategy for SBIRS-Low and these two research and development (R&D) satellites will have less capability than what was ultimately envisioned. In the late 1990s, DOD planned to launch three demonstration satellites, called the Flight Demonstration System (FDS), but terminated that effort in 1999 due to rising costs. Now, DOD is returning to the demonstration satellite approach. Sensors and flight structures built for the FDS satellites will be used for the R&D satellites identified in the restructuring plan. According to that plan, new technologies will be introduced as they mature, with incremental improvements in satellite lifetimes, focal plane arrays, and cryocoolers, for example.

Because the program recently was restructured, and there is no final system architecture, cost estimates are problematic. The General Accounting Office (GAO) reported⁶⁷ in February 2001 that DOD, using the system description at the time, estimated that the life-cycle cost for SBIRS-Low through FY2022 was \$11.8 billion. A January 2002 Congressional Budget Office (CBO) report⁶⁸ estimated the cost through 2015 at \$14-17 billion (of which \$1 billion was appropriated prior to FY2002). In its report on the FY2002 DOD appropriations bill, the House Appropriations Committee reported (H.Rept. 107-298, p. 250) that the program’s life cycle cost had grown from \$10 billion to over \$23 billion. The April 15 restructuring plan did not include a new DOD cost estimate, but said that out-year funding estimates would be developed as part of the FY2004-2009 FYDP.

Two industry teams were chosen in 1999 for program definition and risk reduction (PDRR). The Spectrum Astro/Northrop Grumman team included Boeing, Lockheed Martin, and others. The TRW/Raytheon team included Aerojet, Motorola, and others. DOD had been expected to select one of the teams for the next phase (EMD) in mid-2002. However, as part of the April 15 restructuring plan, DOD decided to merge the two teams. TRW was named the prime contractor, and Spectrum Astro a major subcontractor, for the satellites. Competition at the sensor subcontractor level will continue, though, with Raytheon and Northrop Grumman pursuing independent parallel sensor development to demonstrate on-orbit performance with the series of R&D satellites.

The February 2001 GAO report raised questions over whether SBIRS-Low could meet its technical milestones. GAO concluded that five of six critical satellite technologies were too immature to ensure they would be ready when needed: the scanning infrared sensor, tracking infrared sensor, fore optics cryocooler, tracking infrared sensor cryocooler, and satellite communications crosslinks. GAO also cited concurrency as a concern in that satellite development and production were scheduled to occur at the same time; the results of an on-orbit test would not be

⁶⁷ U.S. General Accounting Office, *Space-Based Infrared System-Low at Risk of Missing Initial Deployment Date*, GAO-01-06, February 2001, p. 3.

⁶⁸ U.S. Congressional Budget Office, *Estimated Costs and Technical Characteristics of Selected Missile Defense Systems*, Jan. 2002, [<http://www.cbo.gov>].

available until five years after the satellites entered production; and software would be developed concurrent with the deployment of the satellites and not be completed until more than three years after the first SBIRS-Low satellites were launched. Other critics cite the ability to discriminate between targets and decoys, and the ability to share information between satellites, as significant technical hurdles.⁶⁹

Recent Congressional Action

Steven A. Hildreth, Specialist in National Defense

FY2006

For FY2006, the Bush Administration requested \$8.73 billion for the Missile Defense Agency.

On May 25, 2005, the House approved its version of the defense authorization bill (H.R. 1815). The House bill includes \$8.83 billion for MDA (an increase of \$100 million for additional testing of the ground-based missile defense system being deployed). The Senate Armed Services Committee marked up its version of the authorization bill (S. 1042) on May 12, 2005, to include \$8.73 billion for MDA. The Committee also specified that \$100 million of the funds added to the Mid-Course Segment should be used to enhance the missile defense test program. The Senate approved its version of the defense authorization bill (S. 1042) on November 14, 2005. The bill specifies an additional \$100 million to enhance the GMD test program.

On June 20, 2005, the House approved its version of the defense appropriations bill (H.R. 2863). The bill includes \$8.58 billion for MDA, adding \$100 million for additional GMD testing and \$82 million to develop a multiple kill vehicle. The Senate passed the defense appropriations bill on October 6, 2005. It included \$200 million for additional GMD testing and \$65 million for the Israeli Arrow system.

FY2005

For FY2005, the Bush Administration requested \$10.2 billion for all missile programs. This included about \$9.17 billion for MDA and about \$1.02 billion for other DOD missile defense programs, primarily in the Army (e.g., PAC-3 and MEADS).

On July 22, 2004, the House and Senate approved a conference agreement that provides \$10 billion (\$9.995) for all missile defense programs. This was signed into law (P.L. 108-287) on August 5, 2004. More recently, the FY2005 defense authorization bill provided \$9.95 billion for BMD programs. This was signed into law on October 28, 2004.

⁶⁹ Robbins, *op cit.*

FY2004

On February 3, 2003, the Department of Defense announced that the Administration would ask Congress for \$9.1 billion for missile defense spending for FY2004, and \$9.7 billion for FY2005.

House and Senate conferees approved the defense appropriations bill on September 24, 2003. The bill was then passed in the House on that date, and in the Senate the following day. The FY2004 defense appropriations act (P.L. 108-87/H.Rept. 108-283) was signed into law on September 30, 2003. The bill provided \$9.1 billion for missile defense programs.

FY2003

In early February 2002, Defense Secretary Rumsfeld announced that the Administration would ask for \$7.8 billion for missile defense spending for FY2003. However, when the MDA provided Congress details of its budget, the amount requested was considerably less (\$6.7 billion). The Pentagon then attempted, as it had the previous year, to remove the PAC-3 program and funding for it from the MDA to the Army. The total amount for Patriot (PAC-3 EMD, modifications, procurement and spares) is \$859 million. MEADS was an additional \$118 million, bringing the combined total request for missile defense spending for FY2003 to about \$7.68 billion. House and Senate conferees reached agreement on October 9, 2002, and approved \$7.6 billion for missile defense programs (H.R. 5010).